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THE CINCINNATI EXPERIMENTS ON WATER PURIfication have been completed and Mr. Geo. W. Fuller, Chief Chemist and Bacteriologist, has submitted his report on the same. He recommends mechanical filtration, preceded by sedimentation. The character and extent of the investigations were set forth at length in our issue of Dec. 8, 1898, except that it was not there stated that a coagulant was being used during the latter part of the tests. The experiments showed that slow sand filtration alone would be sufficient for the treatment of the Ohio River water at Louisville during only 134 days in the year; that this, combined with three days' sedimentation, would suffice for only 231 days, or 64%, of the year. It is therefore considered advisable to use a coagulant, sulphate of alumina, and not over two days of sedimentation, with subsequent filtration. The estimated cost of the system recommended is $9.97 per 1,000,000 gallons, including capital charges and operating expenses, against $10.36 for a "modified system" of slow sand filtration. Either system would effect a satisfactory purification. The cost of the experiments has been $38,260, not including the printing of the report, which it is expected will be published soon.

TWO WATER FILTRATION PLANTS for the U. S. capitol building at Washington are proposed. An act now before Congress authorizes the architect of the Capitol Building to contract with a filter company for two plants, one at each end of the building, of 350,000 gallons each. The effluent must be "bright, clear water." The water "shall be double filtered through two separate filter beds at a rate of not more than 5 gallons per sq. ft. of bed per min., without the use of alum or other chemicals," and "a thorough and efficient method of cleaning and aerating the filter beds shall be employed."

SALT WATER FOR FIRE PROTECTION IN NEW York is provided for in a resolution which has been offered in the city council, asking the Board of Public Improvements "to prepare an ordinance and transmit it to the Municipal Assembly for action, providing for the laying of street mains for the purpose not only of utilizing the pumping capacity of the city's fire boats, but also for the purpose of sprinkling the streets and flushing the sewers of the city of New York." The action of the Chamber of Commerce on the same matter was noted in our issue of Feb. 9.

THE LARGE MACHINE SHOP AT THE BROOKLYN, N. Y., Navy Yard was destroyed by fire on Feb. 15. The building was 375 ft. long and 100 ft. wide, constructed of brick. It was four stories high and contained, besides a large amount of valuable machinery, a quantity of drawing, records and models of battleships and cruisers. Among the latter was one of the ill-fated "Maine." The loss is set at from $700,000 to $1,000,000. The cause of the fire is unknown. A singular incident in connection with the fire is the destruction of the model of the "Maine" on the anniversary of the destruction of that battleship in Havana Harbor.

THE NEW GARBAGE REDUCTION PLANT AT BOSton was badly damaged by fire on Feb. 10. The plant is owned and operated by the New England Sanitary Product Co., of Boston.

A SERIOUS RAILWAY ACCIDENT occurred at Foret, Belgium, on Feb. 18, on the railway running from Calais, France, in which an express train from Calais ran into a train standing at the station. It is reported that 30 persons were killed and fully 50 seriously injured. The accident is attributed to a fog which obscured the signals.

A WOODEN WATER TANK BURST at Redwood City, Cal., a few days ago. It had a capacity of 50,000 gallons and was connected with the city water-works plant.

THE SUNKEN SHIP "Andelana," whose capsize in Tacoma harbor was described in our issue of Jan. 26, may be raised by Mr. Henry Parker, C. E., of Victoria, B. C., if the owners accept his proposition. This is, in brief, to put large hawsers under the vessel and secure their ends to scows; the slack of the hawsers would be taken in at each low tide, and as the tide rises again and lifts the wreck from the bottom it would be towed into shallower water, until it grounded. This process would be repeated until the hull was brought to the surface, when it would be righted and pumped out.

THE WHITE STAR LINER "OCEANIC," which was launched at Belfast, Ireland, on Jan. 14, as was briefly noted in our issue of Jan. 19, is the longest and largest as well as one of the most costly ocean steamers ever launched. The exact dimensions of the vessel as given by the owners are: Length over all, 704 ft.; length between perpendiculars, 685 ft.; extreme breadth, 68 ft. 4½ ins., and depth, 49 ft. The ribs are steel channels 9 ins. deep, with 4½ and 4-in. flanges, and they are spaced 31 ft. 6 ins. apart. The steel plates vary from 1 in. to 1⅝ ins. thick. Over 1,704,000 rivets will be employed in the hull. A double bottom extends the full length of the ship, and is traversed by nine longitudinal webs. Generally this double bottom is 5 ft. 1 in. deep, but underneath the engines this depth is increased about 2 ft. The twin propellers are 22 ft. in diameter, and have manganese bronze blades. The hull for 250 ft. amidships is fitted with bilge keels 18 ins. deep. These, from the manner in which they are attached, form quite a feature of the vessel, and strengthen her considerably. At the turn of the bilge through a considerable part of the ship's length the plating is of double thickness, as are the sheer-strake and the strake next but one below it. The upper deck stringers have been likewise doubled in regard to plating. In this way what may be called an enormous angle has been built up on both sides of the vessel. There are in all five steel decks, besides promenade and boat decks, 13 water-tight bulkheads about 49 ft. apart, and a longitudinal bulkhead 97 ft. long between the compartments to be occupied by the port and starboard engines. At present little can be said of the engines except that they will be four-cylinder, triple expansion engines, with cylinders 47½ ins., 79 ins. and (two) 93 ins. in diameter and 6 ft. stroke. There will be accommodations for 410 first-class, 300 second-class and 1,000 third-class passengers, besides a crew of 390 men. The coal bunkers hold 3,700 tons, sufficient, it is claimed, to take the vessel around the globe in 81 days without recoaling. The vessel is being built by Harland & Wolff, and will cost about $5,000,000.

PACIFIC OCEAN SOUNDINGS are to be made by the U. S. S. "Ranger," from Guam to Manila, to supplement those already made from the United States and Hawaii to Guam. The course to be covered is about 6,000 miles, with deep-sea soundings taken at 10-mile intervals. These soundings will be made with a detachable sinker and No. 11 piano wire; this wire is .03-in. diameter, has a breaking strain of a little over 200 lbs. and it weighs 1.3 lbs. to the 100 fathoms, or about 13 lbs. to the mile. It is said that a length of 2,000 fathoms can be wound in in 14 minutes with the ship steaming at a fair speed. The Sigsbee sounding machine is used, and this automatically registers the fathoms paid out, and has a reel, run by steam, with a capacity of 6,000 fathoms of wire. Three seamen do the manual work and two officers check off the record. The pitching or rolling of the ship is met by a spring counterbalance connected with the wire. The "sounding-rod," also invented by Capt. Sigsbee, is a brass tube, 10 ins. long and 2¼ ins. outside diameter, passing freely through a globular iron casting weighing 60 lbs. The sinker is held on the tube by a catch and loop; and when bottom is struck the lower part of the tube is forced into the mud until the sinker rests on the bottom, the catch is then released and the released tension on the sounding wire is at once recorded on the hoisting machine. The wire is then pulled in, with the tube and sample of bottom, leaving the sinker behind it. The wire is paid out in sounding at the rate of 600 ft. per minute, and can be hoisted at the rate of 900 ft. per minute. As rises of temperature above 70° may affect the gutta-percha insulation of cables, it is important to obtain the temperature at great depths. This is done by a modification of the Negretti-Zambra deep-sea thermometer. This is a mercury thermometer with a cylindrical bulb and straight stem, protected from pressure by being hermetically sealed in a strong glass tube. This thermometer is pivoted with a tendency to upset, and in descending the mercury bulb is down and is kept there by the pressure of a small threaded rod surmounted by a propeller. Just above the bulb the stem is contracted and slightly flattened with a kind of S-bend. When the sounding weight strikes the bottom, the lifting of the wire reverses the action of the propeller, releases the thermometer and the latter tumbles bulb up. This reversal breaks the mercury column at the contraction and the mercury already in the stem falls to the bottom and expanding it records the same temperature existing at the time of reversal, and preserves this record until the thermometer is set for a new observation. The upsetting of the thermometer also releases valves in the top and bottom of metal cups attached to the thermometer and admits samples of the deep-sea water.

THE MINERAL PRODUCTS OF JAPAN are rated as follows in the "Annales des Mines," of November, 1898: The coal output is the most important, and this was 4,268,135 metric tons in 1894 and 4,772,656 tons in 1895. Copper comes next, with 18,005,200 kilograms for 1895; but the output is stationary. Japan is poor in iron; in 1895, the product for the whole empire was only 15,760 tons of cast iron, 4,015 tons of wrought iron and 932 tons of steel. Gold, to the amount of 631 kilograms, and 60,665 kilograms of silver were mined in 1895. Oil territory, in the Province of Eshigo, yielded 12,000 liters of petroleum in 1893.

THE AMERICAN LOCOMOTIVES for the Midland Ry. of England, which are being built by the Baldwin Locomotive Works, were referred to by Mr. J. H. Wicksteed in a speech at the annual dinner of the Yorkshire College Engineering Society, held at Leeds, England, Jan. 28. We quote from a press report of the speech as follows:

The Midland Ry. Co. had ordered 20 locomotives from the United States. The reason for that was that they wanted the locomotives, and could get them in three months from America, and for £500 less per locomotive than in England, where they would have to wait for 15 months nominally—(laughter)—and possibly for two years. (Hear, hear.) These locomotives would be of the mogul type. With a view to safety, the locomotive superintendent had made special specifications as to axles and axle-boxes, and had required a copper fire-box, because with the fuel and water to be used a steel fire-box would not answer. But the rest of the locomotive would be American, and we should shortly have 20 of them running on the Midland Railway for goods traffic, and would see how they compared with English locomotives in cost of maintenance and of fuel. These American locomotives had been used with satisfaction in Mexico and other places, without undue cost of maintenance for five years past, and it was likely that they would be "an eye-opener" to those in Midland shops themselves, and would emphasize the mistake that English working men were making, because, though American workmen produced a locomotive for £500 less, they did not carry less money home, they carried more. (Hear, hear and applause.)

THE AFRICAN CONTINENTAL RAILWAY, to extend from the Cape of Good Hope to Cairo, is being pushed as a project by Mr. Cecil Rhodes, in London, but so far with little success. A gap of about 3,500 miles would have to be covered by the railway, between Khartoum and Bulawayo, and the construction of this line would cost at least $50,000,000, according to the estimates of the British South African Co. Mr. Rhodes does not ask the government for a grant of money to be used in construction, but is seeking a government guarantee on a lump sum, with the hope of a reduced rate of interest. The telegraph line has been carried north to Lake Tanganika, and is now in operation between Cairo and Khartoum. Mr. Rhodes is hopeful of connecting these two lines in the near future, as this line is practically his own private venture. The total length of the telegraph line, from the Cape to Alexandria, would be 6,669 miles; of this the Cape system to Mafeking supplies 870 miles, and the Egyptian system, if carried to Foshoda, would represent 2,090 miles, leaving a gap of about 3,700 miles for the African Transcontinental Telegraph Co. to fill.

THE LUMBER AND PULP INDUSTRIES of New York in the past year consumed 450,995,416 ft. B. M. of timber in Northern New York. This means the practical stripping of 105,000 acres of forest land of all its merchantable timber. No provision is made for future growth, and the State Superintendent of Forests, Wm. F. Fox, in his report, points out the danger of longer leaving these forests under private control.

THE PITH OF CORNSTALKS, powdered, is being experimented with at the Dupont's Powder Works, at Carney's Point, N. J., as an ingredient in the manufacture of smokeless powder. The powder now made is not wholly smokeless and sometimes loses strength in storage. Cotton was tried as an absorbent, but could not be ground fine enough; and it is said that the powdered pith of cornstalks is giving somewhat better results, though the experiments have not yet been conducted to a satisfactory ending.

THE COST OF MARKETING ANTHRACITE COAL is reviewed in the February bulletin of the Anthracite Coal Operators' Association. According to this the cost of coal at the wharf of a retail dealer in New York is from $2.00 to $2.50 less per net ton than the retailer's selling price. The cost to the retail dealer of carrying on his business is only 50 to 25 cts. per ton, leaving him a net profit of $1.25 to $1.50 per ton.

SUBMARINE HARBOR DEFENCE MINE EXPLOSIONS IN BALTIMORE HARBOR.

Submarine mine fields were adopted so generally as a method, and in some cases, as the only available method, of harbor defence during the late war with Spain, that our readers will, we think, be interested in examining the accompanying views of mine explosions photographed while removing the mine fields in Baltimore Harbor after hostilities ceased. These photographs were secured by Lieut. Charles W. Kutz, U. S. Engineers,

Fig. 1.—View of Explosion of Submarine Mine Containing 225 lbs. of Dynamite.
(Depth of mine below surface, 20 ft.; height of top of column above surface, 300 ft.; camera, 500 ft. distant.)

who had charge of the work of removing the mines which defended that port. As most of our readers will probably remember, it was found after the war that it would be too dangerous to raise the mines in many places owing to the fact that the openings provided were too small to remove the dynamite from the shell without risk of explosion. It was, therefore, decided to explode the mines as the safest method.

Referring to the illustrations: Fig. 1 shows the result of exploding a mine of the mushroom type loaded with 225 lbs. of 70% dynamite. This dynamite was not of the best possible quality, but as it was necessary to get the mines planted without delay, it was deemed sufficiently good for the purpose. The photograph was taken with the camera 500 ft. distant. A column of water rose to a height of 300 ft., much discolored with the mud of the bottom. The mine was located at a depth below the water surface of about 20 ft., and some 6 ft. above the bottom. The view shows the appearance of the column of water when it had reached about the highest point to which it rose. The opposite condition or the appearance of the column of water at the beginning of its ascent is shown by Fig. 2. In this view the bulging up of the mass of nearly solid water is clearly shown by its darker color. Fig. 3 shows the simultaneous explosion of a group of three mines, each containing 225 lbs. of dynamite. The columns of water in this case rose almost as high as that shown by Fig. 1, but they appear much smaller owing to the camera being 1,000 ft., instead of 500 ft., distant. Altogether the three illustrations give a very satisfactory idea of the power and aspect in action of the submarine defenses which were hidden under the waters of our great harbors during the period of actual hostilities last year.

AN ELECTRICALLY OPERATED 150-TON REVOLVING DERRICK.*

By Walter A. Post, M. Am. Soc. C. E.†

(With two-page plate.)

Together with the demands of the day for greater capacity, greater power, and greater speed, as essential characteristics of the modern ship, there comes the dependent feature of greater weight, and, to the shipbuilder, the problem attendant upon this feature, namely, that of providing for the economical handling of these weights. The plant of the Newport News Shipbuilding & Dry-Dock Co., although well provided from its origin with appliances for handling material, was found in its later developments to be in need of apparatus more powerful and more convenient than the 100-ton shear legs which, to that time, had been used for handling the heavier weights installed on board ships during the fitting out period.

The growing need of such apparatus had been for some time forcing itself upon the attention of the company, but it was only in the spring of 1896 that it was finally determined to undertake its provision, and steps were taken to ascertain from the experience and opinions of experts, both in this country and abroad, what general type of machine would most satisfactorily fill the particular requirements of the Newport News plant.

The fundamental requirements, briefly stated, were: Capacity to lift and place on board the heaviest single weight liable to be incurred in the probable development of modern ships; a field of operation, as large as practicable, in which these weights could be handled, and absolute precision within this field; a location accessible by the ordinary means of transportation from all parts of the yard; and, finally, that greatest factor defined in all projects by the broadest use of the word economy.

Careful consideration of these requirements lead to the adoption of a 150-ton revolving derrick, electrically operated and controlled, mounted on a steel tower supported in turn by pile foundations. The structure was located on one side of a pier 700 ft. long, forming one side of a slip, in which a number of ships may be moored at one time and readily brought within the field of the derrick's operation. Two standard gage tracks over entire length of pier afford means of transportation from any part of the yard, and also direct connection to the main lines of the Chesapeake & Ohio R. R. system. The floor of the pier, 185 ft. in width, furnishes ample room for the temporary reception of heavy pieces, castings, armor, etc., and permits, in addition, the assembling of much work within direct reach of the derrick, thus allowing assembled parts to be placed on board as a single member, relieving the tendency to overcrowd floor space in the shops and effecting a saving in cost over work as assembled on board ship.

The final design of the derrick was taken up about March 1, 1897, and in July, 1898, 16 months later, weights were being placed on board the battleships in course of construction at the yard. Aside from the steel work in the tower, it was designed, constructed, and erected by the Newport News Shipbuilding & Dry Dock Co., under

Fig. 2.—View Showing Start of Column of Water in a Submarine Mine Explosion.

the direction of Mr. Somers N. Smith, at that time General Superintendent of the works. The design of the derrick itself, including steel tower, jib, hoists, and machinery in general, was prepared by the Steam Engineering Department under Mr. C. F. Bailey; the direct working out of plans and details being assigned to Mr. R. L. Lovell of the same department. The successful completion and high efficiency of the whole machine attested both the care and skill of the designers and the workmanship of the yard force. The steel tower was furnished and erected by the Berlin Iron Bridge Co., of East Berlin, Conn.; while the foundations were designed and constructed under the direction of the author.

A brief statement as to size, capacity, range of operation, etc., may be of interest before proceeding to the description of particular details. The derrick jib, as may be seen by reference to accompanying drawings, is capable of having its outer end raised or lowered, thus giving to the hoisting blocks, which depend vertically from this end, a movement not only of rotation about the center of the derrick, but also of translation in or out from this center. With the outer end of the jib in its lowest position the hoisting blocks will, on rotation of the derrick,

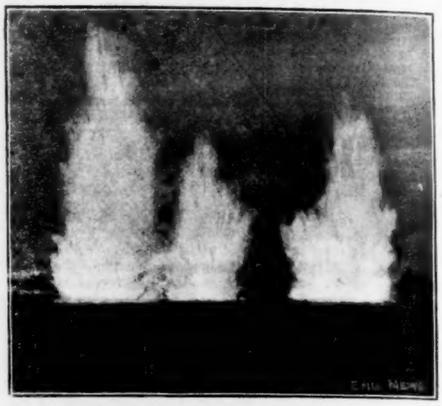

Fig. 3.—Simultaneous Explosion of Group of Three Submarine Mines in Line, Each Containing 225 lbs. of Dynamite.
(Depth of mine below surface, 20 ft.; camera, 1,000 ft. distant.)

describe the circumference of a circle 207 ft. in diameter; with the jib in its highest position these blocks, on rotation, describe the circumference of another concentric circle 88 ft. in diameter, thus permitting the derrick to operate on weights lying anywhere within the circle ring whose maximum and minimum diameters are 207 ft. and 88 ft., respectively. The maximum load of 150 tons can be handled only within a ring whose maximum and minimum diameters are 147 ft. and 88 ft., respectively, but weights up to 70 tons may be handled throughout the entire field of operation. This feature of varying the radii at which the hoisting blocks can operate, constitutes a most important difference between the derrick under discussion and the 130-ton steam crane erected, in 1893, on Finnieston Quay, Glasgow. In the Finnieston crane, which at the time of its construction represented the ideas of best English practice, there is no variation in the radius at which the hoisting blocks are carried, and, in consequence, the field of operation becomes narrowed to a single line, the circumference of a circle described by the blocks on revolving the crane. The advantages of the Newport News derrick are obvious. The maximum elevations, above mean high water, for the hoisting hooks in the high and lower positions of the jib are 118 and 69 ft., respectively; this giving ample clearance vertically for any probable conditions.

Taking up the description of the several parts of the structure, it may be well to follow the actual order of construction and begin with the foundations. A discussion of the conditions which serve to determine the choice between a masonry or pile foundation is obviously beyond the scope of the present paper, and it is sufficient to say that the decision to adopt a pile foundation was reached, not alone after the possibilities of masonry, but also of metal tubes and cylinders filled with cement, had been investigated at much length. The soil at the point of erection is eminently suited to the use of piles, and it is the author's belief, based on a number of years' experience in that locality, that a properly creosoted pile foundation would, under conditions imposed, have about 90% of its original strength retained after a period of 25 years. Assuming the probable life of the foundation to be 25 years, and recurring again to the governing factor of economy, we may, with pertinence, state that the cost of such foundation was about $8,000, and the time consumed in construction about 2 months; while the masonry foundation for the Finnieston Quay 130-ton crane cost in the neighborhood of $45,000, and required 17 months to complete. It is apparent that the interest accumulations on the difference in cost for a period of 25 years is far more than sufficient to renew foundations and re-erect derrick.

The foundations adopted consist of four concentric rows of piles, driven vertically and spaced 3 ft. c. to c., measured on the circumference of each ring; 350 piles were required for these rings, all carefully selected straight

*A paper read at the sixth general meeting of the Society of Naval Architects and Marine Engineers, and copyrighted by the Society. Published by permission.

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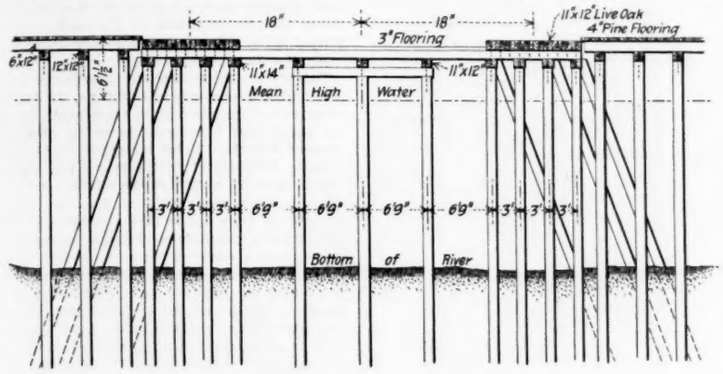
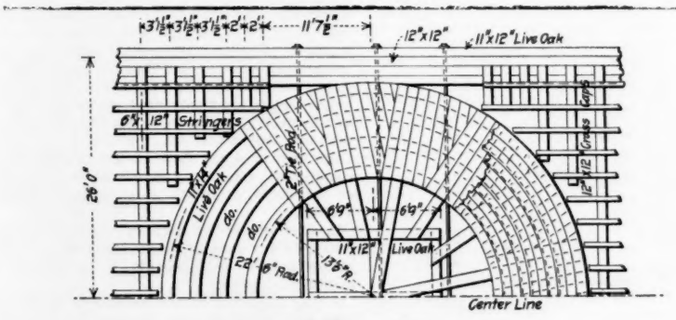
round sticks, measuring not less than 14 ins., 6 ft. from the butt, and not less than 9 ins. at the small end. They were carefully treated with London ordinary dead oil, of approved quality, 16 lbs. per cu. ft., and then driven, under a 3,000-lb. hammer, to an average depth of 28 ft. into the hard bottom of the river. In addition to the above, 70 piles were driven at an angle of 30° to the vertical and secured to the capping by galvanized iron drift bolts, thus giving the entire foundation greater rigidity and stability. The caps are carefully selected live oak, 14 x 11 ins., laid in concentric circles on tops of piles, surmounted in turn by two thicknesses of heavy live-oak flooring, the lower flooring being laid radially across the caps, while the upper one has its lengths laid, similarly to the caps, along the circumferences of concentric circles. The whole assemblage, of caps and flooring, is protected as much as possible from decay, and firmly secured to the piling by galvanized iron drift bolts. It may be well to state, as a concluding remark on the pile foundations, that it is intended to fill the pier solidly around the space occupied by the derrick foundations, thus preserving the piling for an indefinite period from possible attacks of the teredo.

Proceeding to the description of the steel tower:—we have a structure cylindrical in general form, comprised of 16 columns securely braced and anchored, through their shoe plates, to the pile foundatons below, the columns being surmounted by a series of box girders to which



Vertical Section.



Half Plan.

HALF-PLAN AND ELEVATION OF PILE.

FOUNDATION AND PLATFORM FOR 150-TON DERRICK.
Newport News Shipbuilding & Dry-Dock Co.

is bolted the cast-steel track carrying the rollers on which the derrick revolves. The 16 columns are equally spaced over the circumference of a circle 36 ft. in diameter and set square to radial lines through their centers. They are built up of two 15-in. 70-lb. channels, well latticed on the sides, with batten plates, top, bottom, and midway their height, at which point horizontal and diagonal braces connect. The column shoe plates are seated on iron plates 1 7-16 ins. thick, carried by the upper course of live-oak flooring, each shoe being anchored by twelve 1⅜-in. bolts to the piles, if possible, and where not, to the pile caps.

To heavy box girders, surmounting the columns, are riveted at every other column, the ends of lattice girders projecting radially from the center, at which point they connect to heavy gusset plates which serve to build up a central bearing for the 16-in. vertical pin used to center the derrick, and which serves, also, should unforeseen emergency require it, to prevent any lifting tendency of the derrick itself. Projecting outward and downward from the pin bearing, to the base of each alternate column above mentioned, are stiff angle braces, tied at their middle points to the top and middle point of the columns by diagonal and horizontal angles. Diagonal 2-in. tie rods, running from the top and bottom of the alternate columns, which do not carry radial girders, to the bottom and top of corresponding columns opposite, serve, with the above-mentioned angle braces, to rigidly connect and tie together the whole structure of the tower. The circular turned cast-steel track, on which 63 conical cast-steel rollers travel, has a mean diameter of 36 ft. for the roller circle and is so beveled that the top elements of the rollers are always horizontal, thus ensuring an easy turning motion. The rollers are held in place by two concentric circular rings, the inner one built up of plates and angle bulb, the outer one of plates alone; these rings being held in place by 21 2-in. steel rods, radiating from the center pin casting, to which they are secured, and passing axially through every third roller and secured at the same time to both roller rings.

We have now reached the revolving structure or derrick proper, which may be, for convenience of description, divided into two members; the housing, a heavily framed structure containing the generating and controlling machinery, operating platform, and counterweight or ballast; to this is secured the second member, namely, the jib, which, carried by the housing and controlled by the power therein, carries in turn the sheaves and blocks through which all the hoisting power must be finally applied.

Recurring to the housing, a brief description, in connection with the accompanying plates, will suffice to indicate its general character and note interesting features. Resting on the conical rollers is a circular girder; on this is carried the heavy cross-girders which furnish supports and foundations for the generating motors, heavy gearing, drums, and other parts of the machinery. In a central bearing is the 16-in. pin previously mentioned; at one end of the cross-girders is secured, by a 9-in. pin connection, the lower end of the jib, while at the opposite end of the girders rises the ballast tank containing 410 tons of pig-iron ballast. The ballast tank is built up of heavy floor girders, resting on and running at right angles to the cross-girders above mentioned. From the extremities of these floor girders rise the vertical ends of the tank, each end being a hollow box section and serving to transmit the weight of the ballast from the floor of the tank to the 10-in. pin connections at the top of the tank, from which points inclined struts are run downward and across to the ends of the cross-girders which connect with the lower end of jib. The ballast tank overhangs the circular girder, and as only a portion of the weight of the ballast is required to balance the jib in its high position, the remaining weight of ballast is carried, in that case, by the overhanging girders, which are reinforced by brackets on the side. The arrangement of ballast above described brings the center of gravity of the revolving structure always within a radius of 7½ ft. from the center, which, as the path of the roller bearings has a mean radius of 18 ft., gives a minimum factor of stability of 2.4. Thus, with the jib in its highest position and no load, the center of gravity is 7½ ft. behind the center, while with 150 tons load at 73½ ft. radius, or 70 tons load at 103½ ft. radius, the c. g. is 7½ ft. forward of the center. As before referred to, the 16-in. central pin is provided with a top nut and secured below, which thus affords a further safeguard against tilting.

Turning, for a moment, to the jib, attention may be called to the endeavor to so arrange sheaves as to bring the minimum amount of bending and wear upon the pins. The member as a whole is a triangular truss, pin-connected and with its long side in compression.

In taking up now the operation of the derrick we will divide our remarks into three headings, corresponding to the three main movements, namely, revolution, elevation or depression of the jib, and the vertical movement of the hoists. The derrick is revolved by duplicate sets of machinery, each consisting of one 800 General Electric railway motor, capable of developing 20 HP., and driving, through means of a double threaded worm and wheel of the Albro-Hindley pattern, a pinion which, engaging a horizontal circular rack on the outside of the tower, gives the required movement of rotation. The motors are series-wound and controlled from a series-parallel controller, giving high efficiency under starting conditions as well as at normal speed. The turning motion is very smooth and perfectly noiseless, and, as will be seen from the tests, requires very little power.

The racking movement of the jib is effected as follows:—At the inner and upper apex of the jib is a 10-in. steel pin carrying 22 cast-steel sheaves, each sheave of 5 ft. pitch diameter. At the upper apex of the housing is another 10-in. steel pin carrying 24 similar sheaves. Leading over these two sets of sheaves, and sustaining the weight of the jib and load, are two 1¼-in. steel wire ropes; each rope being wound on alternate sheaves and each end of each rope brought down to separate drums, located below in the housing; this arrangement ensuring freedom from side twisting on the sheaves and also requiring each rope to take its share of the weight. The four drums, on which these ropes are wound, are arranged in pairs, each one of a pair taking opposite ends of the same rope and each pair driven by a 2,000 General Electric series motor of 100 HP.; the power from the motor being transmitted to each drum through a separate train of gears. The drums are of cast-iron, 5 ft. pitch diameter, carried by 7-in. steel shafts. Each rope, having 22 parts, is strong enough to sustain and operate the jib when under maximum load, thus guarding against accident and enabling either motor to be disconnected, and the rope, which it controls, to be removed for repairs or renewal. The motors are series-wound, which ensures each taking its proper share of the load.

Passing finally to the hoist, we have two main hoists, each of 75 tons capacity, and one 20-ton whip for lighter loads. The main hoists are each of 12 parts, 1¼-in. steel wire rope, leading over six sheaves, 5-ft. pitch diameter, carried on a 10-in. steel pin at the outer end of the jib. The lead from these sheaves to the operating drum is carried down the jib on wooden roller runners. These drums, one for each hoist, are of cast iron, 8½-ft. pitch diameter, carried on 7-in. steel shafts, and each driven, through a train of gears, by a No. 2000 General Electric 100-HP. motor, series wound. These hoists may be coupled together and operated as one hoist of 150 tons capacity. The 20-ton whip is of three parts, 1¼-in. steel wire rope, carrying a single block and leading over two sheaves, carried, as are those for the main hoist, at the outer end of jib. The lead from these sheaves passes down the jib, over a single guide sheave, to a cast-iron drum, 8½-ft. pitch diameter, driven, through a train of gears, by a 2000 General Electric 100-HP. motor, series wound.

It will be noticed that electricity is used to generate the power required for all the movements of the derrick. The question involved in the choice as to the form of energy to be employed in such a machine cannot be fully discussed here, but the convenience of operation, ease of movement, and general efficiency of the present derrick attest the successful use of electricity in this case. Current is transmitted, over heavy insulated copper wire, to fixed brushes, attached at the center and near the top of the steel tower. These brushes are arranged to bear against circular contact rings insulated from, but carried by, the center casting to which the roller rods are secured. Near the top of this casting are two more contact rings which transmit the current to a pair of brushes, fixed to the revolving part of the derrick, from which the current is delivered over heavy insulated copper wire to the several motors. The current is delivered to the motors, under normal conditions, at a pressure of 220 volts.

Before concluding, it may be interesting to note a few particular features, and to give the result of such tests as opportunity has permitted up to the present time. The brakes are a feature of considerable interest. These were required to occupy little space, be powerful and certain in their action, and to be automatic. This was accomplished by extending the ordinary band brake so that it wound 4½ times around a brake cylinder carried on the shaft to which is keyed the pinion that meshes into the gear of the operating drum. This brings the brake in as direct connection with the load as possible and guards against accidents of the machinery. The brake cylinders are of cast iron, 30 ins. in diameter, with the wearing surface chilled. The band is of wrought iron 1 in. thick, 5 ins. wide at one end, and tapering to 1¼ ins. at the

machines which had been brought to the attention of the Underwriters, every one of which machines was considered in such shape that approval was impossible, so that the use of the machines was absolutely inadvisable. It is therefore evident that each special case, for a time, will have to be considered on its own merits. It would certainly be unwise to assume that further experience might not remove many of the objections here raised, but it is believed that a conservative course is at present entirely justifiable. It is therefore believed that the best advice for any one desiring to-day to put an extensive Acetylene plant into a Mutual risk is, to wait. Let further experiments be made, and if some light must be had at once, put in an electric plant.

FIG. 1.—MAP OF THE ISLAND OF YESSO (HOKKAIDO), JAPAN, SHOWING RAILWAY LINES BUILT AND PROJECTED.
S. Tanabe, Director and Chief Engineer, Hokkaido Government Railways.

THE RAILWAYS OF HOKKAIDO, JAPAN.

By S. Tanabe, M. E.*

Hokkaido, or the Island of Yesso, lies to the north of the main island of Japan and has an area of 30,000 square miles, not including the Kurile Islands. The area suitable for cultivation is estimated at 7,000,000 acres, and it will accommodate a population of 5,000,000, when peopled with the same density as the northern part of the main island. The present population is 800,000, with a rate of annual increase of 8%, and about 400,000 acres of land are under cultivation. The annual product of the fisheries is about 150,000 tons. The extensive coal beds now supply about 500,000 tons annually, and there is a considerable production of precious metals. The climate of the island ranges from 0°F. in winter to 90°F. in summer, but in some parts the temperature reaches as low a point as —30°F. in winter. The depth of snow is about 2 ft. in the east, 3 ft. to 4 ft. in the west and from 4 ft. to 5 ft. in the center of the island. In some localities the snow fall reaches the exceptional depth of 8 ft. to 10 ft. The sea is smooth in summer, but in winter it is rather rough. It does not freeze except along the northeast coast, where, from December to March, drift ice is met with from Cape Soya to Cape Noshapu. This ice has its origin in the northern part of the sea of Okhotsk, and it packs along the shore for a width of from 10 to 20 miles and completely stops all traffic by sea. Other parts of the coast are always navigable.

The first railway in Hokkaido was constructed in 1880 for transporting coal from Poronai to Otaru Harbor, a distance of 55 miles. In 1891 the line was extended to Sorachi, Yubari and Mururn, making a total of 205 miles of railway. This railway is now owned by the Hokkaido Coal & Ry. Co., and has a traffic of 60,000,000 ton miles of freight, including coal, and 1,1600,000 passengers, each year. The location of the line is shown by the map, Fig. 1, which is reproduced from the official map of the Hokkaido Government Railways.

In 1896 the Colonization Railway Act was passed by the Japanese Congress, and work was begun on 600 miles of new line, to be completed in twelve years. These lines were as follows:

Section.	Miles, Length.	Completed, '98.
1. Sorachibuto—Asahigawa	36	36
2. Asahigawa—Soya	180	24*
3. Asahigawa—Akkeshi	227	36*
4. Akkeshi—Abashiri	90	Not com'c'd.
5. Akkeshi—Nemuro	65	"
Total	598	96

*From Asahigawa.

The following is a short physical description of each of these lines:

(1.) Sorachibuto-Asahigawa, 36 miles. For 23 miles from Sorachibuto (80 ft. above sea) the line passes through a flat, fertile plain, with two river crossings, and its longest tangent is 11 miles. From mile 23 to mile 30 the line winds along the steep right-hand bank of the Ishikari River (Kamoikotan as it is called) with numer-

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other. The broad end is firmly anchored, while the narrow end is secured to a lever carrying a weight of 200 lbs. When lowering the jib or the hoisting blocks, the direction of rotation for the brake cylinders is toward the small end of the band, so that the friction, produced by the weight, between the cylinder and band, causes the band to wind tight on the cylinder and stop rotation. In hoisting, the brake releases itself, the friction lifting the weight and uncoiling the band; while any tendency to rotate in the opposite direction causes the weight to fall and the band to tighten. To release the brake it is only necessary to lift the weight, which is done by means of a wire connecting with a lever in the operating house; the lever being always within reach of the operator and the brakes always in operation except as released by continuous pull on the lever.

The operating station is directly underneath the lower end of the jib, overlooking directly the weights to be handled, and encased with glass front as a protection from the weather. The controllers for the several motors are within easy reach of a single operator, who is thus given convenient and absolute control over the varied movements of the derrick. The ropes for the hoist and racking movement are all of plow steel wire, 1¼ ins. in diameter, of 6 strands of 37 wires each, with hemp center and very flexible. Each rope has a breaking strength of 100,000 lbs. The gears throughout, except the worms and those supplied with the motors, are of cast steel with cast teeth, the pinions being full shrouded. These gears work very smoothly and show a high efficiency.

The safety factors attained in the various members are as follows:

	Factors.
For the jib: Members—Lower struts or legs	10
Tension members—eye-bars	9
Inclined struts	7
Wind bracing	12
In hoisting ropes	7
In tower columns	7.5
In tower wind bracing	15

The total weights in long tons are as follows:

Derrick on rollers (no load)	775
Derrick on rollers (maximum load)	925
Entire structure on piles (no load)	926
Entire structure on piles (maximum load)	1,076
Maximum load per pile, taking vertical piles only and considering eccentricity of loading	9.04

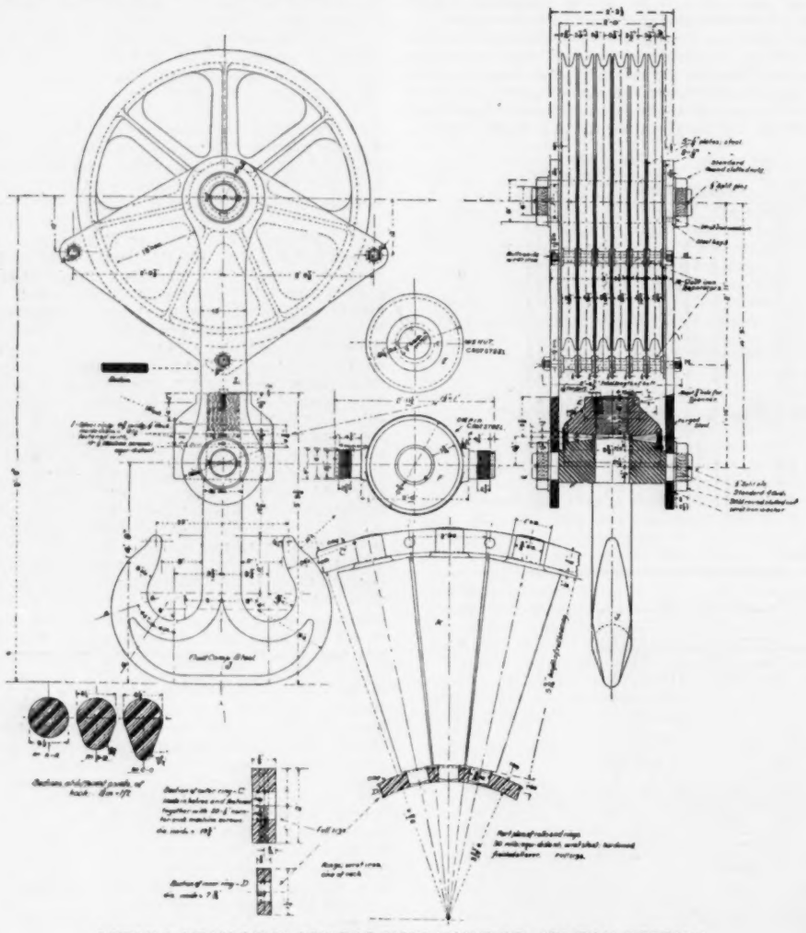
Following is a brief summary of tests:

	Hoists.					
	Right-hand main.		Left-hand main.		Whip	
Net load (long tons)	68.0	0.00	66.0	0.00	19.2	0.00
Speed, ft. per min.	6.05	10.12	7.03	9.08	52.3	84.3
HP. delivered to motor.	54.3	29.2	61.9	30.65	88.9	35.35
Required to hoist load.	28.0	.....	31.4	.....	68.3	.....
Absorbed by mach'y.	26.3	29.2	30.5	30.65	20.6	35.35
Efficiency, %	51.5	.....	50.9	.....	76.8	.....

The difference in power required for the two main hoists is explained by the fact that all gears, except the pair on the motors, have cast teeth, and, consequently, variable friction. All tests were made soon after the completion of the derrick, and still better results may be anticipated when opportunity has been given for the gears to wear smooth.

Moving Jib.

Movement.	Net load.	HP.	Time.
Lowest to highest position	00	89.0 to 64.1	6.9 mins.
Highest to lowest position	00	....	5.56 "



DETAILS OF HOOK BLOCK FOR MAIN HOIST OF 150-TON DERRICK.

The jib has been both raised and lowered with loads up to 66 tons, but, as this was done only in regular course of work, no data was taken. In hoisting, the required power decreases as the movement of the jib decreases. In lowering, power is required to start the machinery, after which the weight of the jib will keep it in motion.

Revolution.

	No. test.				
	1.	2.	3.	4.	5.
Net load (long tons)	134	68	0.00	0.00	0.00
Total weight on rollers	910	845	775	775	775
C. of G., c. of rev'lut'n, ft.	4.28	2.22	1.47	7.00	4.49
Time one revolution, mins.	3.38	3.36	3.04	3.04	3.55
Delivered to motors, HP.	10.71	11.17	11.15	11.15	10.65

The variation in speed and power required was probably due to the influence of the wind, as the observations were taken on different days, with different velocities of the wind. Tests Nos. 3 and 4, taken as near together as possible, show no difference in result, although the position of the center of gravity varied considerably.

In concluding this paper it may be said that the most difficult problem encountered, in the design of the derrick, was that of providing a safe and efficient way of operating the jib, and, in so far as the author knows, the method adopted is, considering the large forces involved, something of a novelty. The results attained and the efficiency of the mechanism would indicate that the problem had been well solved, and that the idea here carried out might, with advantage, be extended by other designers to future problems.

RISKS IN THE USE OF CALCIUM CARBIDE AND ACETYLENE.

A number of members of the Boston Manufacturers' Mutual Fire Insurance Co. have recently applied for permission to adopt acetylene gas for lighting, and a report as to the advisability of this course was called for. The following report was therefore prepared by Mr. E. V. French, Inspector for the company, and is of much interest at this time.

With the present state of the art and the existing prices of Carbide, it is believed that any mill putting in an extensive Acetylene plant is, to a considerable extent, entering unexplored territory. While a great deal of experimenting has been done in this line, there is yet much to learn before a surely satisfactory lighting system is secured. Almost any system at present available requires considerable care and attention in handling the generator. The flame tends, from the great richness of the gas, to become smoky if the burners are not in perfect order. Computations on the present prices of Carbide, and with steam and water power at the cost existing in many Mutual Mills, indicate that it is very doubtful if Acetylene is at all a cheap illuminant.

Waiving for the instant the question of expediency and considering the dangers in Acetylene, the following general properties of the gas may be considered. The figures given are based upon best evidence so far obtainable and are believed reliable. There are many conflicting statements abroad. Mixtures of Acetylene and air, where the Acetylene is from 6% to 25% of the mixture, are explosive, and there is some good evidence that the range may be as great as from 5% to 50%. Comparing this with illuminating gas, mixtures of illuminating gas and air are explosive over a range of from 7% to 18% of gas, showing that the range of explosive mixtures of Acetylene is much wider than for ordinary gas. Explosions of mixtures of Acetylene and air are more violent than mixtures of ordinary gas and air. The weight of Acetylene gas, taking air as 1, is about 0.90, showing that Acetylene gas tends to rise, so that in this respect it is better than naphtha gases, which are heavier than air.

Acetylene gas under some conditions may form Acetylides, i. e., compounds with metals, which are in themselves pure explosives. The best evidence available would seem to indicate that the principal danger is where pure copper is exposed to Acetylene; even then, however, the presence of moisture and possibly some impurities in the gas is probably necessary for the formation of Acetylides. Other metals commonly used apparently are not subject to this danger, and there is considerable evidence to support the feeling that the ordinary small composition fittings used in a gas plant are not dangerous, though any considerable amounts of copper or copper alloys in piping or machinery or in the shape of large fittings, best be avoided.

If, after considering the above conditions, there is still a desire, in any case, to permit an Acetylene plant, the following general requirements, it is believed, should be carefully followed:

1. The generator should be outside of the main buildings and thoroughly cut off from them, preferably in a small building by itself 50 ft., if possible, from important buildings. As a whole it should be treated about like the ordinary naphtha gas machines. The dangers from possible escape of gas in handling the machine, or in repairing it, or by possible ignorance of an attendant, or by accident, and the very considerable dangers introduced if carbide itself is brought into the building, make it appear entirely improper to place one of these machines in a first-class risk.

2. The carbide should be stored entirely outside important buildings, but might be in a compartment of the generator house. It should be looked at about like the main naphtha storage tank of a naphtha gas plant.

3. Before a plant is put in, the complete plans should be submitted to the Underwriters for approval, as there is no standard of construction of machine which can be approved in a general way. There are a number of important features in a machine supplying Acetylene gas needing attention, such as certain limit of pressure, constancy of action, so that there is no chance of the production of gas being stopped and then started again after the burners have gone out, allowing the gas to escape through the open burners. Action such as excessive heating, which tends to bring impurities into the gas, which might make trouble in the building, and other similar points, need careful attention.

The interesting possibilities of the gas have attracted almost an innumerable number of inventors, some careful, but many without experience and a reasonable understanding of the possible dangers involved in handling any gas. Only yesterday the writer received a list of 70

ous curves and two short tunnels. From mile 30 to Asahigawa (330 ft. above sea) the line passes through the flat, fertile plain of Kamikawa. At Asahigawa the line divides, one branch going to Soya and the other to Akkeshi.

(2.) Asahigawa-Soya, 180 miles. At 18 miles north of Asahigawa, the line crosses a ridge having an elevation of 800 ft. above sea. Then gradually descends along the Teshiwo River until it reaches Soya. This line passes through the Teshiwo coal fields.

(3.) Asahigawa-Akkeshi, 227 miles. For about 70 miles from Asahigawa the line passes through a comparatively flat district. It then crosses a ridge of 2,000 ft. above sea level, and several thousand feet of tunnelling is required there. This

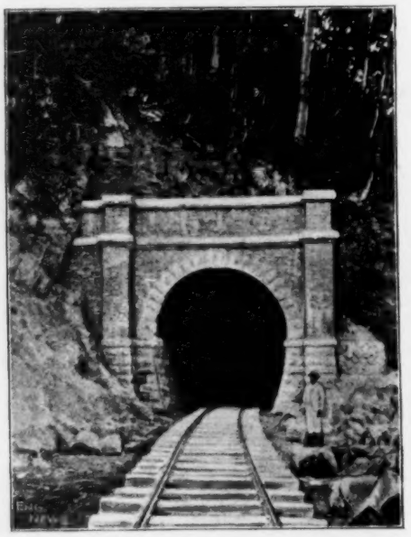


Fig. 2.—Masonry Portal of Kamoikotan Tunnel No. 1, on Sorachibuto-Asahigawa Line, Hokkaido Government Rys., Japan.

mountain section extends about 20 miles when the line again comes to the very flat, fertile district of Tokachi. At 200 miles from Asahigawa it reaches the harbor of Kushiro. From Kushiro to Akkeshi, a distance of 27 miles, it passes through the Kushiro coal field, which is rather hilly, and requires several short tunnels.

(4.) Akkeshi-Abashiri, 90 miles. At about two-thirds of the distance from Akkeshi there is a ridge whose height is 900 ft. above the sea. One or two thousand feet of tunnelling is required in the few miles crossing this ridge. The rest of the line is comparatively flat. The sulphur mine of Kushiro is situated near the ridge.

(5.) Akkeshi-Nemuro line, 65 miles long, is through flat districts.

The gage of these lines is 3 ft. 6 ins., and flat-bottomed steel rails, weighing 45 lbs. per yard are laid on wooden sleepers. Thirteen sleepers are used for a 30-ft. rail. The maximum grade is 1 in 40, and the minimum radius of curvature is 8 chains. The island of Yesso is rich with timber, and the materials imported are rails, wheels and axles, locomotives and machinery. The locomotives are mostly of the Mogul type and weigh from 24 to 50 tons. They are used for mixed service. Passenger cars are generally of the bogie type, 53 ft. in length and 8 ft. wide, with 33-in. wheels and 5 ft. 6 ins. wheel base. Freight cars are also mostly of bogie type, 27 ft. in length and 8 ft. wide, with 24-in. wheels and 4 ft. wheel base. Automatic couplers of the M. C. B. type, with the center placed 24 ins. above the rail level, are to be adopted. All passenger cars have end doors and are heated by stoves.

The principal workshops are at Asahigawa and at Kushiro, with smaller repair shops at Soya, Abashiri, Nemuro, etc. The Asahigawa shops are already constructed. They are laid out in a radial plan and consist of a foundry, and of woodworking, car building, painting, fitting, boiler and machine shops. Typical structures are shown by Figs. 2 and 3. Fig. 2 is a view of the masonry portal of Tunnel No. 1, on the Kamoikota River section of the Sorachibuto-Asahigawa line, and Fig. 3 shows the Sorachi River bridge of the same line under construction.

THE LOSS OF HEAT FROM LOCOMOTIVE BOILERS.

The most elaborate series of tests ever undertaken to determine the loss of heat from locomotive boilers were made last summer by the Chicago & Northwestern Ry. Co., in co-operation with several manufacturers of boiler coverings. A complete report of these tests was given in a paper read at the January meeting of the Western Ry. Club, by Mr. Robert Quayle. The tests were made under the general direction of Messrs. W. H. Marshall and F. M. Whyte and Prof. W. F. M. Goss. The complete paper and discussion is much too long to give space to here; but we have prepared the following abstract containing the substance of the paper:

Plan of the Tests.—In carrying out the tests two locomotives were employed; one to be hereafter referred to as the "experimental locomotive" was subject to the varying conditions of the tests; the other was at all times under normal conditions, serving to give motion to the experimental locomotive, and as a source of supply from which steam could be drawn for use in maintaining the experimental boiler at the desired temperature. The experimental locomotive was coupled ahead of the normal engine, and, consequently, was first when running, to enter the undisturbed air. The action of the air currents upon it, therefore, was in every way similar to those affecting an engine doing ordinary work at the head of a train.

The boiler of the experimental locomotive was kept under a steam pressure of 150 lbs. by a supply of steam drawn from the boiler of the normal engine in the rear. There was no fire in the experimental boiler. It was at all times practically void of water. Precautions were taken which justified the assumption that all water of condensation collecting in the experimental boiler was the result of loss of heat from its exterior surface. This water of condensation was collected and weighed, thus serving as a means from which to calculate the amount of heat lost.

The Experimental Boiler.—The Chicago & Northwestern locomotive, No. 626, the boiler of which served in the experiments, is of the 8-wheeled type, weighing about 90,000 lbs. The principal dimensions of the boiler are as follows:

Diameter in ins.	52.0
Heating surface (sq. ft.)	1,391.0
Total area, ext. surf., not incldg. surf. smoke-box.	358.0
Area of surface lagged (sq. ft.)	219.0
Area of steam heated exposed surface not lagged.	139.0
Ratio of surface covered to total surface	.61

It should be noted that the values given above are based upon projected areas of the plain boiler. No account has been made of the edges of plates at joints, or of surface due to the projection of rivet heads, or to the surface of various attached projections, such as running-board brackets and frame fastenings. While all such projections above the general surface of the boiler are active agents in conducting heat from the interior, the present study does not require them to be taken into account. The extent of area covered for this boiler is entirely normal for the class of locomotives to which No. 626 belongs, which gives added interest to the fact that but 61% of the exposed surface of the boiler was covered.

The tests made were of two sorts: First, with the experimental engine at rest, which test will be hereafter referred to as the "standing test;" and the second, with the experimental boiler in motion at a rate of speed, approximately, 28.3 miles per hour, to be hereafter referred to as the "running test." Both standing and running tests were made with the experimental boiler bare and also when protected by six different coverings. Tests of two of these were repeated, making altogether nine standing tests and nine running tests to be reported. These are designated as follows: A, B, C, D_1, D_2, E, F_1, F_2, and G. "A" represents the test of the bare boiler. "D_1," and "D_2" are different tests of the same covering, and, similarly, "F_1" and "F_2" are tests of a single covering.

Results.—The observed and calculated results are summarized as follows:

Pounds of Steam Condensation per Minute.

	A*	B	C	D_1	D_2	E	F_1	F_2	G
Standing test.	6.78	2.63	3.42	2.91	2.80	3.52	3.04	3.22	3.03
Running test.	14.2	5.68	5.47	5.03	5.34	5.21	5.29	5.30	5.70

*Bare boiler.

The values, as given, have been reduced to a common basis with reference to steam pressure, atmospheric temperature, and running speed, and so far as these factors are concerned, are comparable. They have not been corrected for variations in thickness of covering which, in all cases, was slight, or for variations in the velocity and direction of the wind.

Efficiency of Coverings.—The percentage of the heat transmitted from the bare boiler, which is saved by any covering, may be obtained by subtracting the amount of condensation for the covering in question from the condensation for the bare boiler, and by dividing one hundred times this difference by the condensation for the bare boiler. The result expresses the efficiency of the covering. Values thus obtained are as follows:

Efficiency of Coverings as Disclosed by Running Tests (per cent.).

B	60.2
C	61.7
D_1	64.8
D_2	62.2
E	63.5
F_1	62.9
F_2	62.8
G	60.1

The results appearing in this table are corrected for variations in steam pressure, atmospheric temperature and speed, but not for variations in weather and wind conditions or for variations in thickness of covering. The average efficiency disclosed by the eight tests is 62.3%.

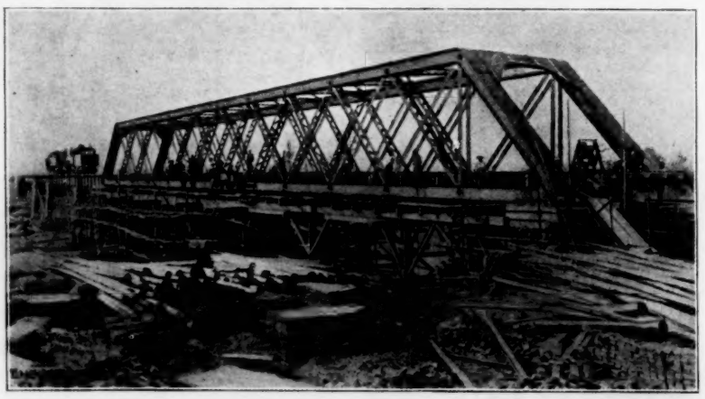


FIG. 3.—SORACHI RIVER BRIDGE ON SORACHIBUTO-ASAHIGAWA' LINE, HOKKAIDO GOVERNMENT RYS., JAPAN.

The conclusion, stated in very general terms, is that any of the coverings tested can be relied upon to save from 60 to 64% of all the heat which would radiate from the boiler were it not covered at all.

One Reason for Similarity of Results.—The fact that the results obtained from the several coverings are so nearly alike can hardly fail to occasion surprise. Had thin layers of the material tested been subjected to carefully planned laboratory tests, the results would doubtless have differed more widely, but it must be expected that the value of such difference will diminish as the specimens experimented upon are increased in thickness. A material which is rather an indifferent non-conductor will serve to prevent the passage of heat if applied in sufficient thickness. While, therefore, the coverings tested were of normal thickness, it would seem that this thickness is sufficient to reduce to a negligible amount the effect of the superior non-conducting properties which the material of one covering may have possessed over others.

Efficiency of Covering and Heat Loss from Different Portions of the Boiler.—The results show that the covering of 61% of the exterior surface of the experimental boiler saves 62.3% of all the heat radiated from the same boiler under similar circumstances, when bare. It does

not, however, follow from this statement that if 100% of the exposed surface of the boiler were covered, 102% of the heat lost from the bare boiler would be saved. Such a conclusion must obviously be absurd, though a hasty consideration of the facts presented might seem to justify it. The fact, as first stated, however, proves that there is a vast difference in the character of the exposure to which different portions of the boiler are subjected. While only 61% of the surface of the boiler was covered, the protection was evidently applied where it was most needed. The percentage of the total exposure guarded against was greater than the percentage of surface covered. For this reason, increasing the covered area by 10% cannot be depended upon as a means of reducing radiation losses by a like amount. It will reduce loss, but the amount of the reduction may be very much less than 10%. It is for this reason, also, that all comparisons in this report have been based upon the boiler as a whole. The radiation is stated in terms of pounds of steam condensed per minute for the boiler experimented upon, rather than as pounds per minute per square foot of exposed surface. The latter unit would be a more general unit, but its use in interpreting the data under consideration would be misleading.

Radiation and Its Power Equivalent.—Assuming that a locomotive will develop a horse power by a consumption of 26 lbs. of steam per hour, and assuming that the steam thus consumed must be generated from water at 80° F., the radiation losses already given may be expressed in terms of power losses of equal value. The practical effect of these assumptions is to define a horse power as equal to the condensation under the conditions of the tests of 34 lbs. of steam per hour, the steam having a pressure of 150 lbs. and the water the temperature due to this pressure. Upon this basis the following results are obtained. They apply only to the boiler tested:

Power Lost by Radiation.

	Horse-power equivalent to radiation losses.
Bare boiler.	
Locomotive at rest, under conditions of test	12.
Locomotive running 28.3 miles per hour and otherwise under conditions of test	25.
Boiler lagged as in test:	
Locomotive at rest, under conditions of test	4.5
Locomotive running 28.3 miles per hour and otherwise under conditions of test	9.

A locomotive similar with that tested may be expected to deliver a maximum of 600 HP. It is evident that if the uncovered boiler were under conditions of speed, etc., which are not now uncommon in service, that at least 10% of the total power of the machine would be lost in radiation from its exterior surface. This, then, discloses the extent to which locomotive performance may be affected by radiation. A perfect covering enveloping the entire external surface of the boiler would prevent the entire loss. Actual coverings, such as those tested, extending over a portion of the surface, prevent approximately 62.3% of the loss. It seems to be a fact, therefore, that a boiler protected in accord with good practice loses power when standing in warm weather, at the rate of 4½ HP., which amount will increase if the pressure of steam is increased, or the temperature of the atmosphere is reduced, or the engine is put in motion.

Cost of radiation from the boiler experimented upon may be stated as follows:

Bare Boiler.

Pounds of coal per hour equivalent to radiation losses, assuming evaporation from and at 212° F., of six pounds of water per pound of coal—	
When standing	60
When running 28.3 miles per hour	126
Tons of coal per month, assuming boiler to be under steam standing 200 hours and running 28.3 miles per hour during 300 hours per month	25
Cost of radiation per year for the boiler tested, assuming the conditions of the preceding paragraph and assuming the price of coal $2 per ton	$600

As locomotives are never run entirely bare, the estimated annual loss by radiation, of $600 per engine, is higher than would be likely to occur on any engine in service. It is, however, a statement of the total loss which may occur, and as such will be useful in estimating the value of savings which may be effected by the application of coverings.

It has been shown that the several coverings tested have an efficiency which is not far from 62.3%. The annual saving, therefore, which would be effected by the application of any of the coverings would be

$$\$600 \times .623 = \$383.80,$$

the remaining $226.20 still going to waste through radiation. The results show that anything which will increase the efficiency of the covering on the engine tested by 1% will result in a saving of $6 per annum. A 2% increase of efficiency will save $12, a 3% increase $18, and so on. This holds good for the particular engine tested and for the conditions under which the engine was tested.

The fact should be emphasized that the results thus far given are those derived from the actual experiments. These involved a boiler of moderate size, carrying steam pressure which is now regarded as low, and were conducted in the month of August. It should be noted, also, that the running tests involved a speed of less than 30 miles per hour. It is evident that other conditions, quite common to actual service, would operate to greatly increase the radiation losses described. The effect of changes in some of these conditions will next be considered.

WEATHER TABLE FOR JANUARY, 1899. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Degrees Fahrenheit.) Average.	Max.	Min.	Range.	Wind. Velocity in miles per hour. Average.	Max.	Direction at time of max. velocity.	Precipitation—Rain or melted snow. (Inches.) Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	15.2	58	−20	68	10 3	48	SW	1.77	0.70	12
	Portland, Me.	23.3	52	−10	62	7.8	28	NW	3.39	0.76	10
	New York City	30.8	56	5	51	15.1	66	NW	4 08	1.48	12
	Pittsburg, Pa.	31.4	66	5	61	7.3	37	NW	3.41	0.16	14
	Chicago, Ill.	23 0	48	−13	61	19 6	52	W	0 58	0.34	9
	Omaha, Neb.	25.1	58	−15	73	8.8	36	NW	0.07	0.03	5
	St. Paul, Minn.	13.7	41	−26	67	8.5	36	NW	0.87	0.49	8
	Duluth, Minn.	9.4	37	−32	69	10.2	48	NW	0.67	0.36	8
	Bismarck, N. Dak.	8.6	48	−25	73	10.4	52	NW	0.09	0.03	6
	Average	20.1	52	−15	73	10.9	45	—	1.66	0.58	9
Southern Cities.	Washington, D. C.	33.6	60	−1	61	6.5	32	NW	4.12	1.29	14
	Louisville, Ky.	35.0	64	4	60	10.1	49	SW	4 30	1.46	12
	St. Louis, Mo.	32.6	61	−4	65	10.7	37	W	1.66	0.66	11
	Savannah, Ga.	50 6	76	30	46	9.0	38	NW	3.59	1.21	11
	Kansas City, Mo.	30 9	61	−5	66	10.7	36	SE	0.28	0 12	5
	Jacksonville, Fla.	55.2	78	38	40	7.9	32	SW	3 98	1.68	17
	Chattanooga, Tenn.	40 8	62	18	44	7.6	42	SW	4.82	1.50	13
	New Orleans, La.	53.4	75	29	46	8.6	42	NW	2.44	0.82	13
	Memphis, Tenn.	40.6	66	7	59	11.1	48	SW	5.78	2.17	13
	Palestine, Tex.	46 6	70	18	52	7.4	24	NW	5.48	1.83	9
	Average	41.9	67	13	54	9.0	38	—	3.64	1.27	12
Western Cities.	Helena, Mont.	22.3	49	−18	67	7.7	42	SW	1.60	0.48	13
	Port Crescent, Wash.	—	—	—	—	—	—	—	—	—	—
	San Francisco, Cal.	53.0	78	40	38	7.9	47	SW	3.67	0 96	11
	Salt Lake City, Utah.	33 8	54	16	38	6.0	36	S	0.84	0.48	8
	Santa Fe, N. Mex.	26.6	48	9	39	7.1	36	N	0.19	0.11	5
	Denver, Colo.	30.4	58	−5	63	9.0	50	NE	0.65	0.24	7
	Yuma, Ariz	—	—	—	—	—	—	—	—	—	—
	Average	33.2	57	8	49	7.5	42	—	1.39	0.45	9

The effect of changes in speed on radiation has long been an open question. It has been argued that a boiler perfectly covered would be, to a very great extent, unaffected by surrounding air currents, and hence that its radiation losses would not be materially greater when the locomotive is at speed than when standing. But those who appreciate the intensity of the cooling currents which circulate about a locomotive when at speed, have been slow to accept such a view, and the tests under consideration confirm their position. They give a measure of the radiation losses, both when the locomotive is at rest and when moving at a uniform speed of 28.3 miles an hour. While these points are not sufficient to establish with accuracy the complete relationship of radiation and speed, an estimate of real value may be based upon them. Such an estimate shows that the bare boiler, when at rest, radiates sufficient heat to condense 6.78 lbs. of steam at 150 lbs. pressure, per minute, which amount is increased to 28 lbs. when the same boiler is driven at a speed of 80 miles an hour. Similar values for the covered boiler are 3.0 lbs. and 10.6 lbs. respectively.

Changes in Atmospheric Temperature.—The results recorded was obtained in midsummer and all have been corrected for an atmospheric temperature of 80° F. For each 10° reduction in atmospheric temperature below 80°, the radiation may be expected to increase 3.5%. For a zero temperature the radiation losses recorded in this report should be increased by about 28%. For example, if, when the atmospheric temperature is 80° the conditions are such as result in the condensation of 5 lbs. of steam per minute; when the atmospheric temperature is zero the condensation will be

$$5 + 5\ (.035 \times 80) = 5 + 1.4 = 6.4.$$

From this it appears that very low temperatures are attended by radiation losses of considerable magnitude.

Changes in Steam Pressure.—The experiments were conducted under a boiler pressure of 150 lbs. by gage. With an increase of pressure the boiler temperature will become higher, and the radiation losses will, as a consequence, be augmented. Changes arising from this source, however, are not great. For each 10-lb. increase of pressure above the limit of 150 lbs. the radiation may be expected to increase by about 1.6%, but this will not apply for pressures much above 200 lbs. A pressure of 200 lbs. will involve losses by radiation which are 8% greater than those making up the record of this report.

Possible Losses from the Boiler Experimented Upon.—Applying the results expressed in the preceding paragraphs, it can be shown that with the boiler bare and the locomotive running at 80 miles an hour, under a steam pressure of 200 lbs., with the atmospheric temperature at zero, the loss by radiation would be the equivalent of 67 HP., while a covered boiler running under the same conditions of speed, pressure and atmospheric temperature, would still be subject to a loss of 25 HP. As a locomotive similar to that tested may be expected to deliver a maximum of 600 HP., it is evident that under the extreme conditions just assumed, which are not at all uncommon to service, at least 10% of the total power of the engine would be lost in radiation. This is for an uncovered boiler. An application of any of the coverings tested would reduce the loss to about 4%.

Size of Boiler.—In reviewing the facts presented in the preceding paragraphs, it will be well to keep in mind the fact that the boiler tested was one of moderate size. Many boilers are now running which present an exposed area which is at least 50% greater than that presented by the boiler under test, and it should be evident that the losses from such large boilers will be greater than those disclosed by the tests under consideration. For boilers of the same general type the loss will probably be proportional to the exposed surface.

Conclusions.—In view of the very strong air currents which circulate about the boiler of a locomotive at speed it is not surprising that the losses by radiation are large. While their value is dependent upon conditions which may vary widely, they always go on whenever the boiler is under steam. In this respect radiation losses are unlike those which occur within the engines of the locomotive, since, to a considerable extent, these latter cease to operate whenever the throttle is closed.

All of the experimental results and the conclusions based upon them were obtained from an engine of moderate size, carrying a pressure which, in the light of modern practice, must be considered low, and under conditions of summer atmosphere. The running speed, also, was not high. These conditions cannot be considered as in any way calculated to disclose large radiation losses, and yet the results are such as will merit the earnest attention of all who are interested in improving locomotive performance. In this connection it will be well to again emphasize the fact that the losses which have been measured and which are defined in this report do not include radiation from saddles and cylinders, or from any portion of the locomotive excepting the boiler itself.

It may be assumed that the boiler as covered in each of the several tests involving covering, was as well protected against radiation as is the average boiler of American locomotives, notwithstanding the fact that when thus covered there is still a loss of heat, which in money value annually represents many times the cost of the best covering which the market to-day affords. Improvement is to be found not only in improving the character of the covering itself, but chiefly, probably, in extending the covered area of the boiler and projections attached thereto.

SHRINK AND FORCE FITS is the title of an article in the "American Machinist" for Feb. 16, giving the results of a series of experiments made by Messrs. Jno. Haralson and J. L. Wood at the Alabama Polytechnic Institute. These experiments consisted in shrinking and forcing steel spindles into cast-iron disks and afterwards pulling some out and twisting the others in the holes. The disks were 6 ins. in diameter and 1 in. thick, with a ¼ × 2 in. boss cast on one side, and were drilled and bored to 63-64-in. diameter and finally reamed to 1 in. The spindles were made of good quality machinery steel 1¼ ins. in diameter, turned and ground for a distance of 1¼ ins. from the end to a diameter varying from 1.001-in. to 1.003-in. About half of these spindles were forced into the holes in the disks by means of a testing machine, the maximum pressure required being noted; the others had disks shrunk upon them, the disks being heated only enough to admit the spindle. The data obtained indicates that both in tension and torsion a shrunk fit, properly made, is about three times as strong as the corresponding force fit of the same size, and that the maximum force was required to start the spindle in both cases.

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The most inviting opportunity for capitalists that we know of anywhere is now presented by the announcement that the Sanitary District of Chicago is open to proposals for the lease of the great water power which will be created at the lower terminus of the Chicago Drainage Canal when that is opened a year or so hence. We have often urged that in neglecting to provide for the utilization of this water power, Chicago was throwing away an asset of enormous value, and one which would go far towards making the drainage canal pay for itself without cost to the taxpayers of Chicago. When the Drainage Canal was first projected, a great deal was said about its value to Chicago as an avenue of transportation, to connect Lake Michigan with the Illinois River; and its value in creating a great water power was hardly mentioned. Now that the city is undertaking to secure the development of this power, however, we are strongly of the belief that for every dime which Chicago may gain through the use of the Drainage Canal as a waterway, it will gain a dollar through the rental of its water power. The latter gain will be a direct one, moreover, resulting in cash payments for the relief of the taxpayers of the Sanitary District, while the benefit from the canal as a waterway will at best be indirect.

We publish on another page the invitation for the submission of proposals which the Sanitary District has issued. According to the figures given by the Chief Engineer, there is an available fall of 34.5 ft. at one site and of 20 ft. at another. Taking the flow in the channel at the minimum of that fixed by law (300,000 cu. ft. per minute) we have a total horse-power in the falling water of about 25,500 HP. Making reasonable assumptions for the loss in turbines, penstocks and tail races, we have about 18,000 HP. as the net available on the turbine shafts.

The cost of the head and tail races for developing this power may be estimated at about $3,300,000, from the figures given by the Chief Engineer of the Sanitary District; but it is announced that the lessees may deduct the cost of this work from their yearly rentals until it is paid for, and that this may also be done for the wheel-pits. Thus the lessee of the water power will only have the turbines and electric generating and transmission machinery as a fixed investment. Under these circumstances the risk to the leasing company and the investment necessary for it is the smallest possible.

The most attractive feature, however, of the Drainage Canal water power is the absolute certainty that all the power developed can be sold at a high price. While the amount of power to be developed is large, it is small compared with the demands of Chicago, and it is this proportion between the demands of a city and the available supply of power that largely determines the price at which a water-power electric transmission plant can dispose of its current. The first and most profitable use of the current from any such plant is to displace the steam-generated current in existing electric lighting plants and electric railways. If there is more power available than can be disposed of in this way, it is generally the case that the rest must be sold at considerably lower prices. The beauty of the Sanitary District water power, as a financial proposition is that every bit of current that can be produced can be sold to furnish current to existing electric lighting and railway systems in Chicago and Joliet. Under these circumstances, it seems to us that the Sanitary District power ought to be marketable for at least $40 to $50 per HP. per annum, and perhaps for even a larger figure.

Another great advantage of the Sanitary District power is that it is continuous for the whole 24 hours, and is thus well suited to the operation of electrolytic refining plants, the drainage pumps in connection with Chicago's sewerage system and for other places where continuous operation at uniform load over the whole 24 hours is essential. We trust that sufficient competition may be aroused for this profitable franchise to secure for Chicago the full amount it is worth.

THE LOSS OF HEAT FROM LOCOMOTIVE BOILERS.

We publish on another page of this issue an account of the most elaborate series of tests ever undertaken to measure the loss of heat from a locomotive boiler under the conditions of service. According to these tests a locomotive boiler of moderate size, lagged as in ordinary practice (that is, with the barrel of the boiler covered with a good non-conductor and the stay-bolt surface around the firebox left bare), will lose while running at moderate speed in summer weather about 4,500 B. T. U. per minute in round numbers, or the equivalent of the heat obtained from about half a pound of average coal burned in the locomotive firebox. That is to say, according to these tests we can assume the radiation loss from a locomotive boiler in summer weather to require the burning of about 30 lbs. of coal per hour.

The tests appear to have been made with great care by acknowledged experts, with intent to make the test conditions correspond to those of actual practice. There is one feature which seems to have been overlooked by the experts, however, which operates in practice, to considerably increase the amount of heat lost over that shown by the test. This feature is that the experimental boiler had only steam in it, whereas a locomotive boiler in service contains water, and probably three-fourths of the surface which it exposes to the radiation has water instead of steam on the inner side. Now, as every one knows, water is far more efficient in transmitting heat to a surface with which it is in contact than steam of the same temperature. If we have water in contact with a plate on one side and air on the other, the plate will be kept at almost the same temperature as the water. On the other hand, if a plate has air on one side and steam on the other, the plate will be at a temperature somewhere between the air and the steam. Thus the outer surface of a boiler shell filled with steam and exposed to the atmosphere will not be as hot and will not radiate as much heat as if the boiler were filled with water at the same temperature.

In the boiler tested, the shell was covered with lagging and the outer firebox sheets were left bare, as in ordinary locomotive practice, and it is stated that the surface covered was 61% of the total surface exposed to steam heat. The whole boiler was first tested bare, however, and comparing the loss of heat from the boiler when bare and when covered with lagging as above, it was found that the lagging reduced the loss of heat by 62.3% as an average. The conclusion is drawn by the authors of the paper that the heat losses per square foot of boiler surface exposed to radiation are less on the firebox than on the barrel of the boiler when both are left bare.

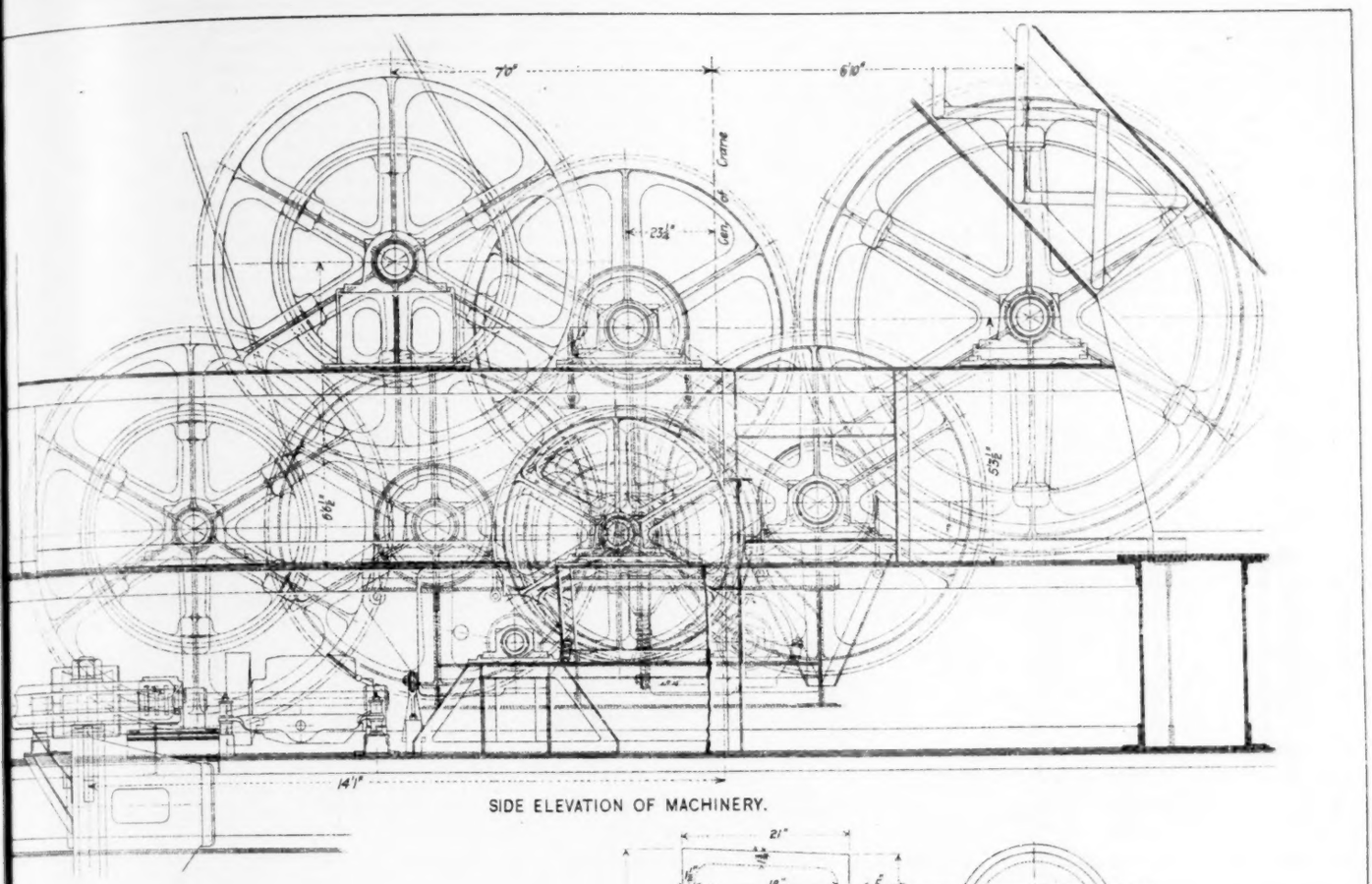
This is a fair conclusion, under the conditions of the tests, if they were correctly made; but it is nevertheless a very surprising conclusion; and for the reasons given above, we do not think it applies to practice. That is to say, with the boiler filled with water, practically the entire surface not covered with lagging is kept considerably hotter than was the case in the tests just concluded, and it will consequently radiate more heat to the atmosphere than it did under the test conditions.

Again, under the conditions of the test with the whole boiler bare, the only reason for the loss of less heat per square foot from the firebox than from the barrel of the boiler would be less circulation of air about and against the outer firebox sheets. It is true that the cab and foot-plate protect in some degree a part of the firebox sheets; but, on the other hand, the front of the firebox and the sides are fully as much exposed as the barrel of the boiler.

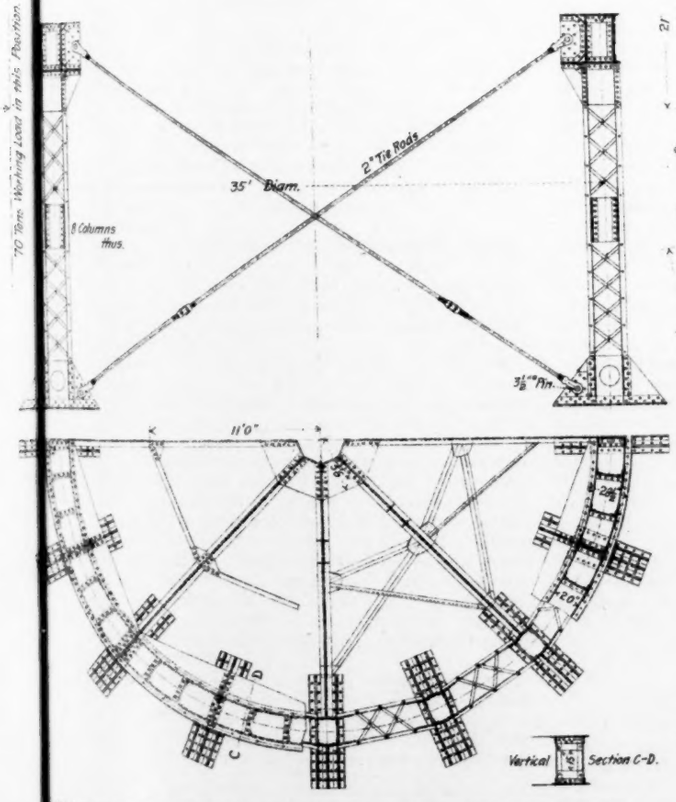
Taking it all in all, therefore, we are inclined to believe that in practical locomotive operation a larger proportion of heat is lost through the uncovered surfaces than is indicated in the paper, and that this is especially the case in severe winter weather.

Referring again to the paper, it will be seen that while the tests were made under a special set of conditions, viz., warm summer weather and light winds, it has been attempted to obtain from these tests figures for the heat losses in winter weather. We look with much doubt upon the soundness of the assumptions upon which these computations were made. These assumptions were that the loss of heat would increase by 3½% for each reduction of 10° in the temperature of the atmosphere and by 1.6% for each increase of 10 lbs. in the boiler pressure. The basis for these figures is not given in the paper, but in an appendix it is stated that corrections were made for slight variations in the temperature of the steam and of the atmosphere in the different tests on the assumption that the loss of heat was directly proportional to the difference of the temperatures inside and outside the boiler. So far as the corrections which were made to reduce all the tests to a uniform atmospheric and steam temperature are concerned, the error introduced by the above assumption is small; for the variations from the standard conditions in the tests were trifling. When this assumption is used, however, to compute the loss of heat from a locomotive at winter temperatures, it is very doubtful whether the results obtained add much to our knowledge. It is true, broadly speaking, that the loss of heat from a boiler increases with increase of temperature inside it, and also with decrease of the atmospheric temperature; but this variation is not so definite that any accurate computation can be made to determine the loss at one temperature from the ascertained loss at another.

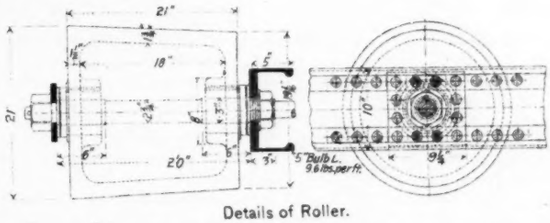
A clearer idea of the variations in the heat losses from a locomotive under varying conditions may be obtained by studying the accompanying diagrams, in which we have shown graphically the conditions which govern the flow of heat from the interior of a boiler to the outer air. In each case the temperature of the steam or water inside the boiler is taken at 365° (corresponding approximately to a gage pressure of 150 lbs.) and the air outside in Figs. 1 to 4 is supposed to be still and at a temperature of 80°. It will be seen that the heat in flowing outward has to meet with three separate resistances in the case of bare plates and with four resistances in the case of



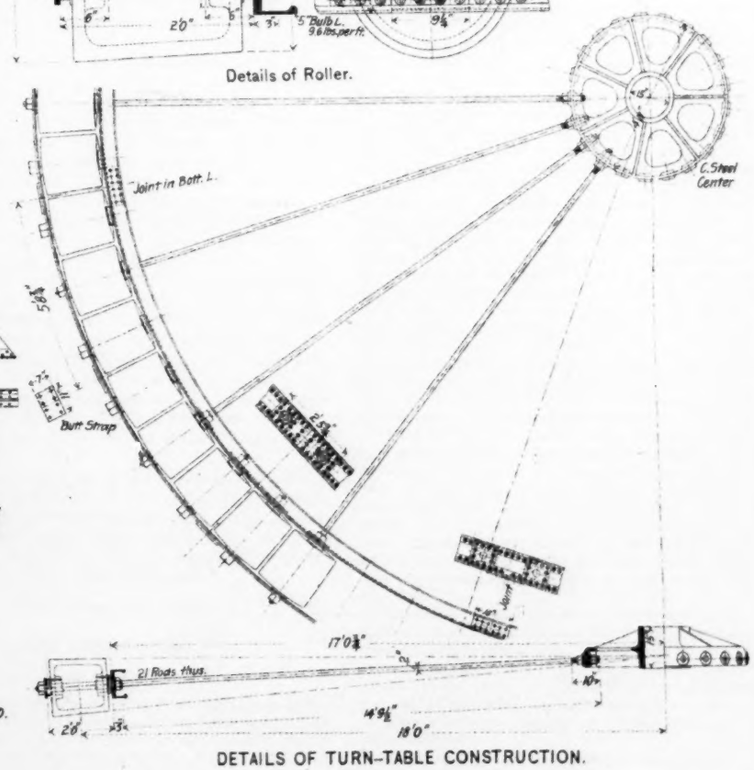
SIDE ELEVATION OF MACHINERY.



HALF PLAN AND VERTICAL SECTION OF TOWER SHOWING TIE RODS.



Details of Roller.

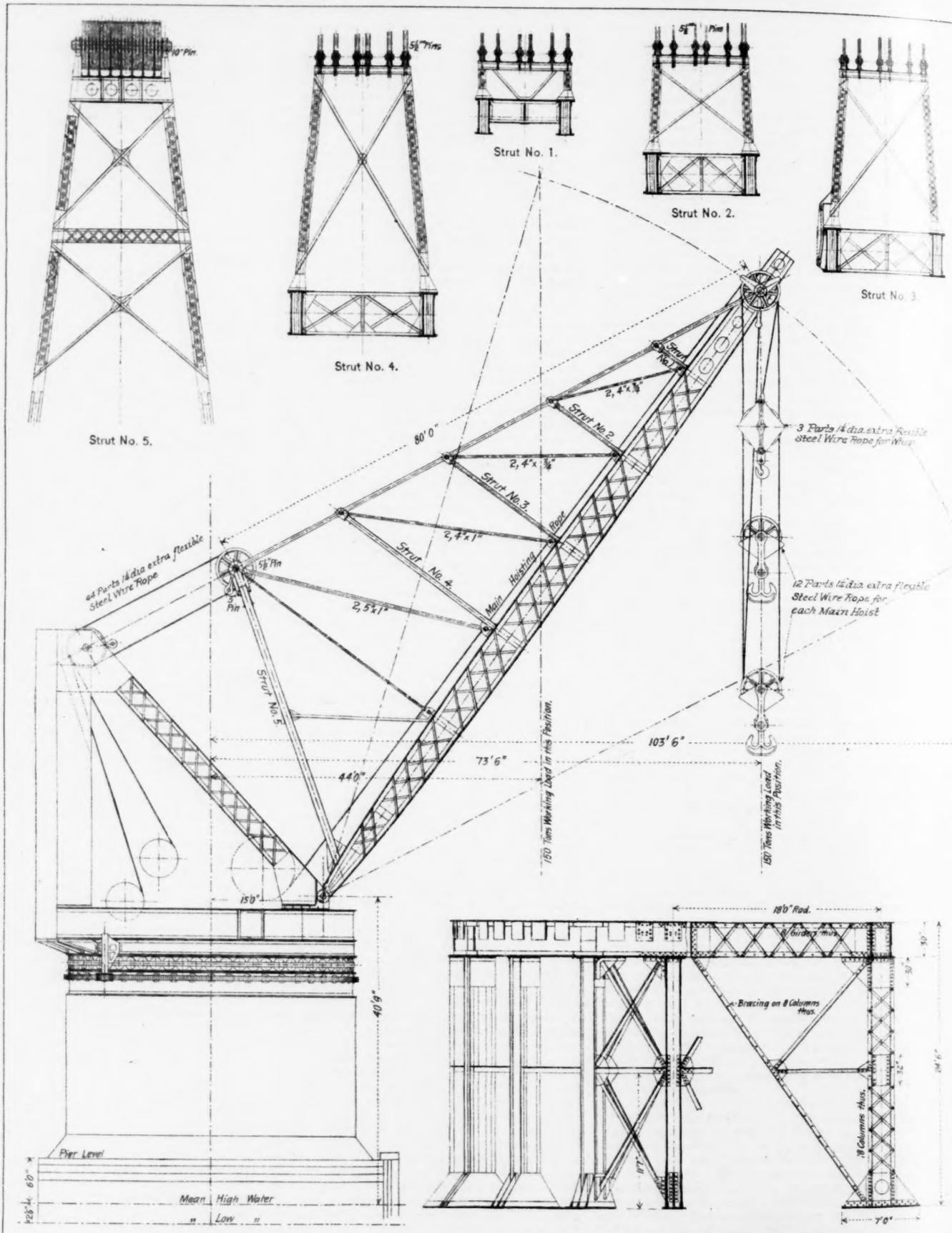


DETAILS OF TURN-TABLE CONSTRUCTION.

THE NEWPORT NEWS SHIP BUILDING & DRY DOCK CO.

Berlin Iron Bridge Co., Contractors for Superstructure.

CHAS. HART, LITH., 30 VESEY ST., N. Y.



GENERAL ELEVATION OF DERRICK.

HALF ELEVATION AND HALF RADIAL SECTION OF TOWER.

150 TON REVOLVING DERRICK FOR THE NEW PORT

C. F. Bailey, R. L. Lovell, and Walter A. Post, Designing Engineers.

lagged plates. There is first the resistance to the flow from the water or steam to the inner side of the boiler plate; second, the resistance to the flow through the plate (a very small factor in all cases); third, the resistance to the flow through the lagging, if the plate is covered, and finally the resistance to flow from the outer surface of the lagging or the boiler-jacket to the outer air. To make clear the part which each one of these resistances plays in influencing the loss of heat from the boiler, we have represented the flow of heat in each case by a dotted line, whose course illustrates the drop in temperature caused by each resistance, and a rough approximation of the probable temperatures at each point is marked on the diagrams, merely to make the facts which the diagrams show more easy to comprehend*.

Comparing Figs. 2 and 4, the fact that much greater loss of heat occurs when unlagged portions of the boiler are filled with water than when filled with steam is made plainly evident. In the latter case the iron surface in contact with the air is kept at almost boiler temperature, while in the other case this surface will be about 100° cooler than the steam inside the boiler.

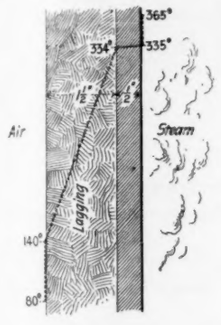


Fig. 1.—Loss of Heat from Lagged Boiler Plate Heated by Steam.

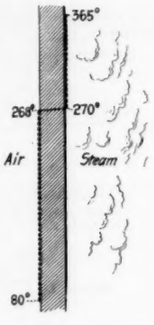


Fig. 2.—Loss of Heat from Bare Boiler Plate Heated by Steam.

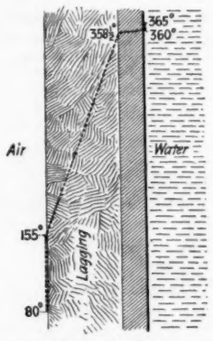


Fig. 3.—Loss of Heat from Lagged Boiler Plate Heated by Water.

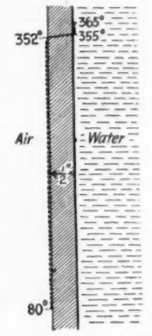


Fig. 4.—Loss of Heat from Bare Boiler Plate Heated by Water.

In the case of boiler surface covered by lagging, however, a comparison of Figs. 1 and 3 shows that the difference in the loss of heat in the two cases is much less. The non-conducting cover keeps the shell of the boiler so warm that when water replaces the steam there is only a small rise in the temperature of the inner surface of the lagging and a small increase in the loss of heat through it.

Next let us consider the effect of wind upon the loss of heat. Referring to Figs. 1 and 3, it will be seen that when a current of air strikes the outer side of the lagging or the boiler-jacket over it, the heat will be carried away more rapidly and the temperature of this surface will fall, thus increasing the rate of flow through the non-conducting cover. An equilibrium will be reached when the boiler-jacket reaches such a temperature that the flow from it to the air just equals the flow through the lagging. The total loss of heat is proportional to the difference of temperature of the two sides of the lagging. Assuming the temperatures of Fig. 3 to be approximately correct for the conditions in still air, the difference of temperature of the two sides of the lagging is 203½°. Suppose that a wind of fifty miles per hour reduces the temperature of the outer side of the lagging as low as 100°. It will only increase the difference of temperature on the two sides of the lagging and the consequent loss of heat about 20%.

Let us turn now to Fig. 4, which fairly represents the flow of heat from the outer plates around a locomotive firebox. Suppose now that a strong wind impinges against the plate. It will carry off vastly more heat than still air and there will be no such cooling of the surface and consequent reduction of the flow as takes place when the wind impinges against a lagged surface. The seething mass of highly-heated water in close contact with the plate on the other side keeps the outer skin of the plate almost as hot as the water itself, no matter how hard the wind may blow, nor how fast it may carry off the heat.

Let us study next the case of variations in temperature. Figs. 5 and 6 illustrate probable temperature conditions under which the flow of heat would take place when the thermometer was 10° below zero, and no wind blowing. It will be seen that the difference of temperature between the surface exposed to the air and the air surrounding it is increased 84° in the case of the bare plate, and only 15° in the case of the lagged plate. Whenever the locomotive is run, however, the boiler is exposed to a strong wind. Under these circumstances the loss from the bare surface will be still further increased over the loss from the plates in still air, as explained above.

We said at the outset that the tests showed an average loss of heat, with the boiler lagged as in service, corresponding to a fuel consumption of about 30 lbs. of coal per hour with the engine running in summer weather. Had the boiler been tested with water inside as well as steam, we think it is likely that this loss of heat would have been increased by 10 to 20%. Certainly this loss of heat represents a drain on the coal pile that is deserving of more consideration than it has received in the past. The old-time wooden lagging, put on because it is cheap, ought to be forever discarded, and an approved modern non-conducting covering applied. The most important lesson of these tests, when properly interpreted, however, seems to us to be the need of protecting in some way the firebox sheets, which are now left bare. It is true that there are mechanical difficulties in the way of applying ordinary non-conducting material to these surfaces; but it does not follow that some sort of protection might not be applied. If even the open cab reduces so largely the loss of heat from the portion of the boiler inside it, it is probable that even a metal housing or a thin sheet of asbestos board to protect the exposed sides of the firebox would be of great value.

We trust it may be found feasible to continue the tests undertaken by the Chicago & Northwestern in severe winter weather. Actual figures as to the heat losses which occur under such circumstances would do much to impel railway officers to take action in this matter.

*Of course it is true that the resistances might be still further divided, and the resistance to the flow from the outer surface of the plate to the lagging, and from the lagging to the sheet metal jacket which covers it might be considered. To do so in the present discussion, however, would serve no useful purpose, as all these resistances, great or small, can be considered as part of the resistance to transmission through the lagging.

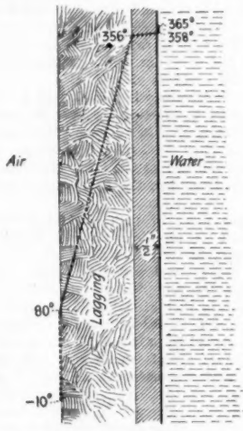


Fig. 5.—Lagged Plate.

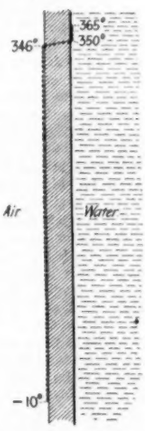


Fig. 6.—Bare Plate.

Loss of Heat from Locomotive Boiler Plates in Still Air at — 10° F.

THE DISTANT SIGNAL.*

By E. D. Wileman.**

Before attempting to describe what this much-abused member of the family should be, let us agree upon the requirements of its service. They can all be condensed into this: that it shall expedite traffic with absolute safety.

In order to see how this may best be done, take a supposed installation, which, while a very difficult one, shall yet be perfectly possible, for it is only an extreme case that makes it necessary to cover all the points in question. A grade crossing at the foot of a long descending slope, approached by a long 10° curve to the right, through a heavy growth of timber, near a large stream with swampy banks. The long descending grade is just easy enough to allow heavy freight trains to drift down with little or no restraint, until they attain almost express speed. The 10° curve and the dense timber make it impossible to see a signal more than 400 ft. away, and the heavy fogs that pervade the valley every chilly night and morning during the spring and fall render everything quite invisible, until within at least 50 ft.—often less. The character of the traffic is such that it would never do to impose a speed on freights that would permit a stop in 50 ft. after seeing the home signal; nor would it answer to allow the "Fast Mail" and the "Limited" to crawl down that slope at a rate slow enough for even the "emergency" to hold them in 50 ft. The almost unvarying regularity with which they get the crossing, owing to the infrequency of trains on the opposing road, also becomes a factor in the problem, rendering it all the more imperative that due notice should be given when a stop is necessary.

In deciding the needed distance between the home and distant signal, it was readily conceded by all concerned that it must be equal to that within which the regular freight trains could be brought to a stand on that grade, which was finally settled upon as 2,500 ft. This was allowing for the maximum train, with half air and two lively men on the rear portion. As the derail was 500 ft. from the crossing, on account of the steep grade, this meant over 3,000 ft. from the tower to the distant signal. This, combined with the sharp curve, made it very doubtful whether a good clear action could be secured with a mechanical signal; hence it was decided to use an electric semaphore of the motor type; and as distance made so little difference in its operation, and a little extra gain in that respect would be so great an advantage to the traffic at this place, it was placed 1,000 ft. farther up the hill, thus giving an actual distance of 3,500 ft. for the heaviest trains to stop in.

As it was quite imperative that this signal should always be cleared when possible, an annunciator was put in, with its section of track 1½ miles beyond the distant signal, the extra distance being needed by reason of the towerman's frequent absence from the lever room, he having to care for the lamps and the outside connections. A still further reason for the annunciator was the difficulty in judging the direction of sound, owing to the sharp curve and dense wood. Should too many unnecessary delays occur to irregular trains, a still further precaution will be taken by a train-describer, worked by the operator at the next station, making it as near certain as possible that the towerman will know in time of the approach of a train.

This signal is controlled by a circuit through the track from the home signal onward, which also passes through a breaker on the home blade, and is worked by a closing contact mounted on the locking frame, so that the last half of the reverse stroke of the home lever's latch completes the circuit, providing the home blade is reasonably close to a perfectly clear position, on which account it is made pipe-connected.

As the signal is entirely invisible from the tower, there is a back indication, or repeater, controlled by a closing contact on the blade, that takes effects during the last fifth of the stroke. The advisability of a tell-tale for the lamp was considered, but as the lamp was the globe-ventilator pattern, with all the in-draft at the top of the body,

*Abstract of a paper presented at the Philadelphia meeting of the Railway Signaling Club, Feb. 21.

**Assistant Engineer; Lake Shore & Michigan Southern Ry.

and extra well cared for, the probability of its being out was so remote that it has not been put on.

The special reason for putting the controlling circuit through the track was to enable the towerman to clear the home signal for a train that had been held at the crossing, and yet be in no danger of showing a clear distant to a closely following train, unless he was ready to let it pass.

Having, so far as possible, insured that the distant signal should be always operated, it became necessary to provide against the chance of the towerman getting confused and changing the route after an engine had passed the distant at clear. To accomplish this, there was an electric lock placed on the facing-point lock lever, controlled by an interlocking relay, so arranged that the lock took effect as soon as the train came to a short track section just beyond the distant signal, and was withdrawn when the last car had passed off a similar section just beyond the trailing derail. The hand-release with this lock consisted of a slow screw, which on its last turn closed a local circuit on the lock, the time required to operate it being more than enough to allow a train to pass from the distant signal to the crossing. The screw was held in its normal position by a seal which, when broken, could only be restored by the inspector. It was also interlocked with the machine locking, so that it could not be operated unless the signals were all at danger, and had to be put entirely normal again before any of the signals could be cleared.

The above outlines a satisfactory installation at a very difficult location, and seems to successfully solve the problem of giving correct information in advance of the position of the home signal. If in the horizontal position, its indication means to use caution, as the home signal may be at danger; and if at clear, then the home signal must also be at clear.

What weak points are there in such an installation? What better arrangement to suit the conditions would it be practicable to use. For, surely unless there is a chance of a wrong indication being given with its probable disastrous results, the business requirements of to-day for high speed service demands that all reliable information that will assist the trainmen in the safe and expeditious handling of their trains should be provided. The most radical advocate of fixed distant signals would surely be unable to claim either expedition or safety in the use of one at such a place. In short, a fixed distant signal can never expedite traffic, as you must always approach a home signal at such a speed as will allow you to stop at it after seeing it, whether that distance be 5 ft. or 5,000 ft., unless you have other means of knowing that it is clear.

Had the alinement been straight, and the extra distance less valuable, the problem would have been met by a mechanical solution, using the regular distant signal on a separate lever, with a multiplier either at the tower or the post; possibly both, for under favorable conditions such signals can be successfully worked as much as 4,000 ft. from the tower.

Any mechanical distant signal on a separate lever should always work through a wire lock at the derail, though that is not so essential if the home is pipe-connected and bolt-locked with the derail; and perfect safety can seldom be secured without the application of electric locking, combined with the slow-hand release under seal.

Though it is seldom desirable to give to an interlocking signal any of the characteristics of the block signal, unless combined with Sykes' locking, should the same effect be desired as was secured by the track circuit on the signal just described, it may be had by the use of an electric slot, or even a mechanical slot, with a track treadle. A still cheaper device would be a short loop on the annunciator circuit connected to a couple of rails just beyond the signal, with a rule that the towerman should put the lever normal as soon as contact ceased on the loop.

Another extreme case—almost the opposite of the one just disposed of—is where there is lack of space for the machine, as in the engine room of a drawbridge, rendering separate levers for the distant signal quite impossible, which was met by making the home signals pipe-connected, with an extra long balance lever, to which the distant wires were connectced, thus working the two signals tandem off the home lever. It is on perfectly straight track, not far from a stop-crossing; hence the speed is always low, and the accessories of electric locking and annunciator were not considered necessary. It has so far given perfect satisfactcion in every way.

Another type of distant signal in frequent use, is where the home and distant were put in tandem with the old home and distant movement. These were very difficult to keep in good adjustment, especially when much worn, and they are fast being replaced with plain balance levers, making them simultaneous instead of successive, but much more positive in action, with no difficulty to speak of in adjustment.

Another form of distant signal that was frequently used several years ago was that connected with what is known as the wheel machine, the only peculiarity worthy of mention being that (as usually connected) it was a continuous run from the tower through the motion plate to the distant pole and back, the home signal being worked by a loop off the distant wire, thus rendering it possible for the home signal to break loose and be at danger with a clear distant. The situation, however, would not be dangerous, as the motion plate at the derail has to complete its work before either of the signals can be clear. While these wheel-machine plants are very simple in every respect, and, if carefully watched, are very safe and seem to be endowed with the proverbial nine lives of a cat, they are quite unpopular, and I have yet to find any one who is not glad to be rid of an old plant.

The almost universal connection to a distant signal in English practice is a single line of wire cable, depending entirely upon a weight to carry the signal back to normal, which, being quite heavy, requires a corresponding counterweight on the lever tail to enable the towerman to operate it. While this has a very dangerous appearance, it must have proven fairly satisfactory to be continued, and one prominent American road has a couple on trial. The other extreme from a single line of wire is a pipe-connected distant signal, a few of which are being tried. At first thought they would seem unreasonably expensive, but actual experience may possibly prove the reverse.

There is a point in connection with the use of any two-line wire-connected signal that has so far received very little attention, yet becomes quite important on long lines to distant signals. It is the possibility of the back wire breaking and allowing the unbalanced strain of the front wire to pull the signal clear. This may easily be corrected by a tripping device, which casts off the front wire if the back one gives way, but otherwise holds everything solid. A very clever form of this is in use on the Chicago, Milwaukee & St. Paul Ry.

At the first thought of this paper, a list of questions, with a circular letter requesting information, was sent to all the trunk lines of the United States and Canada and several roads in England, with the idea of being able to make up a list of percentages regarding current practice. As only 22 roads replied, and so few of those reply [illegible] the number of each type of signal in use, it is entirely impossible to give percentages of any value. I will endeavor, however, to give those who did answer the benefit of the following summary of what was received:

Eleven roads have fixed distant signals in use. As to whether they have been erected as such, or changed to fixed from some other form, the answers are not all definite.

Eleven roads have repeaters on distant signals that are not visible from the tower—only three, however, saying that they use them at all such places.

Only 7 out of the 22 use wire locks on the distant signals, while 2 replied that they are unnecessary by reason of their using separate facing-point locks.

Ten roads are using some form of tandem distant signal, but the answers are not clear enough to venture on details.

Two roads have pipe-connected distants, though one of them has only one example.

Five roads are using distant signals, with a single line of wire connections. Only one of these, however, is in the United States, and that has only two signals, by way of experiment. The maximum distance from home to distant varies from 785 to 3,200 ft., and the minimum ranges from 250 to 1,800 ft.

Ten roads have some form of electric locking, but the replies are not very definite as to the manner of its application.

Eighteen roads have some form of announcement in use, but only one states definitely that it uses annunciators at all crossings.

Eighteen roads make some use of detector bars at crossings to assist in holding the route, but nearly all the replies are quite indefinite as to details.

Five roads make no reply to the question regarding the number of distant signals maintained, but the number given aggregate over 6,200.

Two roads give a maximum distance from tower to distant of 4,200 ft., while four more exceed 3,000 ft.

There were so few replies to the question regarding the distance for stopping the maximum train on the steepest descending grade that a summary would have no value.

CARRYING A 30-IN WATER MAIN OVER AND THROUGH A MASONRY ARCH BRIDGE AT HARTFORD, CONN.

A novel method of carrying a 30-in. water main over a masonry arch bridge at Hartford, Conn., where the space between the crown of the arch and the roadway was only 18 ins., was described before the recent meeting of the Connecticut Society of Civil Engineers and Surveyors by Mr. E. D. Graves, Consulting Engineer for the work. Mr. Graves has kindly sent us drawings showing details of the work, which are reproduced in Fig. 1, and also a view showing the supporting girder ready to be lowered into place, Fig. 2. We cannot better describe the work than by quoting from Mr. Graves' paper, as follows:

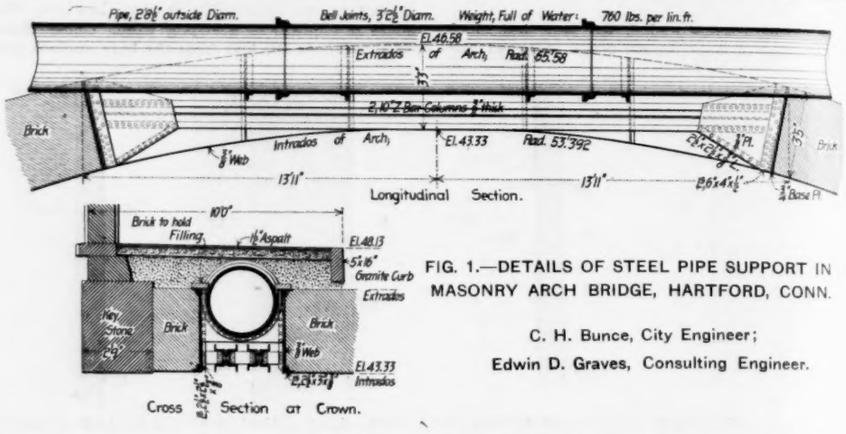


FIG. 1.—DETAILS OF STEEL PIPE SUPPORT IN MASONRY ARCH BRIDGE, HARTFORD, CONN.

C. H. Bunce, City Engineer;
Edwin D. Graves, Consulting Engineer.

The task was accomplished by cutting out a section of the arch ring itself 3¼ ft. wide and 29 ft. 10 ins. long, and replacing this section of the brick work through the whole depth of the arch ring by a steel girder, appropriately designed to carry the water pipe and also to take the thrust which would have ordinarily been carried by the portion of the brick ring removed. The water pipe is laid in circular cradles, riveted between the two plate girders, which are built to conform to the curve of the arch ring both outside and inside. These plate girders carry the vertical load, consisting of the weight of the pipe, the filling and the pavement, and the travel. The brick work is built up closely against the outside of each girder and against the base plates at each end. Underneath the water pipe and extending the whole length of the opening, are two 9-in. "Z" bar columns, connected to the same base plates at each end as the side girders. These columns are designed to carry the horizontal thrust of the arch for the portion of the arch ring removed. The girders and columns in combination form a compact box girder about 30 ft. long by 3½ ft. sq., which was built and shipped and placed in position in one complete piece without field riveting or bolting. This work was so carefully done that the steel girder fitted the curve of the wooden centers closely at all points and performs the work designed for it to do satisfactorily, and so far as is known is an entirely original method of treating this problem. This girder weighed complete about six tons. It was painted three coats of Detroit graphite paint before being built in place. The water pipe was laid in place and calked ready for use before the removal of the centers.

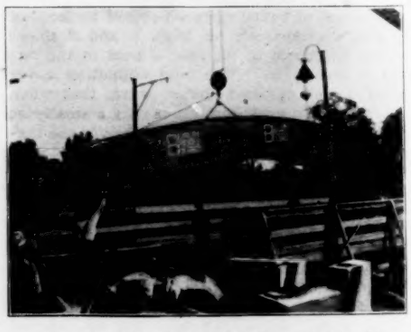


Fig. 2.—Swinging Steel Pipe Support into Place.

The clear span of the bridge is 54 ft., and its rise is 7⅛ ft. It was built in 1898. The structure will be described in detail, with items of cost, in the forthcoming report of the society. Some of its main features were outlined in our report of the above-named meeting, Jan. 12, 1898.

THE REPORT OF THE PITTSBURG WATER FILTRATION COMMISSION.

Pittsburg has long been a notorious example of that large class of American cities which puts quantity above quality in the matter of water supply. Its high typhoid death rate for years past has stamped it as a city with a polluted water supply, while the great turbidity of the water at times is evident to all who see it. The use and waste of water has steadily risen until in 1897 it was about 230 gallons per capita, an increase of 40% in twelve years. There has been some demand, all the time, for pure water, but until quite recently it has been a mere infant's wail compared with the strong cry for more water. A growing agitation for better water finally resulted in the appointment of a commission of eleven members by the city council to investigate the need, available methods and cost of improving the quality of the water supply. This commission has just reported in favor of a combined system of sedimentation and slow sand filtration, and of a thorough meter system to curtail the enormous waste now going on. The report will not be available in printed form for some weeks. Through the courtesy of Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., Consulting Engineer to the Commission, we are able to publish an abstract of it.

The commission organized with Mr. Robt. Pitcairn as Chairman; Mr. Wm. McConway, Vice-Chairman; and Mr. Geo. L. Holliday, Secretary. Mr. Morris Knowles, Assoc. M. Am. Soc. C. E., served as Resident Engineer; Dr. W. Riddle, Chemist; Mr. Wm. R. Copeland, Bacteriologist. Special investigations and reports were made, as follows: On typhoid fever in Pittsburg, Prof. Wm. T. Sedgwick; on a gravity supply, Mr. Emil Kuichling, M. Am. Soc. C. E.; on bacterial contents of city water, Dr. Eugene Wasdin; on driven wells, Mr. A. B. Sheperd, Superintendent of Water-Works. Each of the gentlemen named, aside from the commissioners, made separate reports, but our abstract is from the report of Mr. Hazen, unless otherwise stated. Mr. E. M. Bigelow, Director of Public Works, is one of the members of the Commission.

The greater part of Pittsburg's population (234,000 of an estimated total of 320,000) is supplied by the city from the Allegheny River. The Monongahela Water Co. supplies some 78,000 people from the Monongahela River, and the remaining 8,000 are supplied by two other private companies. The investigation was confined chiefly to the city supply, from the Allegheny.

The drainage area of the Allegheny River above the intake is about 11,400 square miles. The most important cities and towns in the drainage area had a total population of 121,705 in 1880, 185,939 in 1890, or 11 and 16 per square mile, respectively. The estimated population for 1900 is 278,000, or 24 per square mile. Only seven of 59 towns in the list are credited with a population of 10,000 or more for 1,900. In the first 21 miles there are but five towns, all but one of which is below 2,000. Tarentum, 14 miles above the intake, had 4,627 inhabitants in 1890, and it was estimated that it will have doubled in size by 1900. Aside from Tarentum, the estimated populations for 1900 do not reach 5,000 for any one town for over 60 miles from the intake; Latrobe, with 7,100, being the second place of size. At 89 miles, Johnstown is reached, with 21,805 people in 1890 and 43,610 for 1900. The most remote place on the list is 282 miles distant. Only a few of the towns have sewers, but both sewer systems and populations are rapidly increasing. "As compared with other rivers used for municipal supplies in this country and Europe," Mr. Hazen states, "the urban population is comparatively small, and most of it is far removed from the intake, but the stream is a rapid one, so that pollution reaches the intake quickly." The subject will be mentioned again, in connection with Professor Sedgwick's report.

The Allegheny River water is always turbid, and occasionally muddy. Part of the suspended matter is now removed by sedimentation, but this is far from sufficient. Turbidity was measured during the experiments by noting the depth at which a platinum wire was just ready to disappear from view on being sunk in the water. The reciprocals of these readings is used in the records. Thus, with the wire disappearing at 33 ins., as during low water and dry weather, the turbidity is 0.03. The ordinary maximum turbidity of the river is 1.0, this being exceeded but three times during the observations, as follows: March 23, the highest freshet, 2.38; May 17, 1.20; Aug. 20, 1.75. The record for the year ending July 31, 1898, is as follows:

Turbidities.	Days, No.	Days, Per ct. total.	Turbidities.	Days, No.	Days, Per ct. total.
Above 1.00	2	0.5	0.06 to 0.10	94	25.7
0.51 to 1.00	21	5.8	0.02 " 0.05	133	36.5
0.21 " 0.50	51	14.0			
0.11 " 0.20	64	17.5	Avg., 0.17	365	100.0

TABLE I.—Summary of Results from Sand Filters by Months.

Months, 1897-8.	Turbidity, raw water.	Bacteria, per cu. cm. Water Raw.	Bacteria, per cu. cm. Water Setld.	Bacteria, per cu. cm. Effluent, Nos. 1.	Bacteria, per cu. cm. Effluent, Nos. 2.	Efficiency, per c't. No. 1.	Efficiency, per c't. No. 2.	Net yield million gallons per acre, daily. No. 1.	Net yield million gallons per acre, daily. No. 2.
August....	0.19	2,089	1,283	46	42	97.80	97.99	2.40	2.30
September.	0.05	2,478	1,231	16	16	99.35	99.35	2.98	3.00
October....	0.04	72,878	39,186	32	32	99.96	99.96	2.90	2.95
November.	0.24	25,220	29,924	346	632	98.63	97.49	2.64	2.42
December..	0.19	14,433	14,923	163	225	98.87	98.44	2.76	2.46
January...	0.27	15,333	13,826	334	310	97.82	97.98	2.77	1.87
February..	0.15	9,430	12,043	266	275	97.18	97.08	2.93	2.27
March.....	0.30	11,747	12,347	71	332	99.40	97.17	2.95	2.83
April.....	0.08	5,010	4,298	33	91	99.34	98.18	2.95	2.99
May.....	0.19	10,800	6,770	110	99	98.98	99.08	2.93	2.95
June.....	0.19	11,100	5,930	135	72	98.78	99.35	2.83	2.85
July.....	0.11	16,800	13,000	74	89	99.56	99.47	2.94	4.97
August....	0.36	15,100	10,250	51	82	99.66	99.46	2.85	4.82
Average.	0.18	16,340	12,693	129	177	99.21	98.92	2.83	2.98

Note—No. 2 was operated with raw or unsettled water from July 24 to Dec. 19, and from Feb. 20 to June 30; otherwise settled water was applied to both filters.

TABLE II.—Composition of Allegheny River Water Before and After Settling, and After Passing Through Sand Filters, for 13 Months Ending August, 1898.

	River.	Gate chamber.	Settling basin.	Effluent filter. No. 1.	Effluent filter. No. 2.
Color	0.29	0.29	0.27	0.09	0.09
Alkalinity	2.89	3.05	3.07	4.13	4.22
Total solids	15.90	15.50	13.10	12.10	12.1
Suspended mat'r.	4.20	3.90	1.30	0.00	0.00
Hardness	3.58	3.67	3.69	4.72	4.83
Chlorine	2.19	1.99	2.08	2.06	2.02
Sulphuric acid ..	1.44	1.47	1.38	1.44	1.44
Iron	0.0514	0.0724	0.0605	0.0160	0.0179
Nitrogen as					
Free ammonia.	0.0019	0.0019	0.0019	0.0016	0.0016
Albu. ammonia	0.0116	0.0115	0.0108	0.0063	0.0064
Nitrates	0.0684	0.0695	0.0641	0.0715	0.0647
Nitrites	0.0000	0.0000	0.0000	0.0000	0.0000
Bacteria	17,405	16,314	12,663	129	176

Comparisons of turbidities and river heights showed no definite relation.

The population on the Monongahela River shows the same average per square mile, 24, as on the Allegheny, but it is nearer the intake and the pollution is believed to be worse. Mr. Hazen assumed that eventually the whole city will be supplied from the proposed filter plant on the Allegheny River.

Objects and Methods of the Experiments.

The object of the filtration experiments was "to determine the power of sand filters to deal with water as muddy as that of the Allegheny, and to ascertain what bacterial efficiencies could be secured by mechanical filtration, and to afford information on some purely local problems." Each type of filter was employed as then developed, without attempts at modification in design. Besides these filters the Fischer system of filter plates, as employed at Worms, Germany (see Eng. News, Sept. 8, 1892), was tested.

There were two sand filter beds, each, according to Mr. Knowles' report, with an area of about 280 sq. ft. These, and a 33,000-gallon settling basin, were built in concrete. The settling basin afforded 24 hours' sedimentation when supplying one filter at the rate of 5,000,000 gallons an acre a day. One filter was operated with raw and the other with settled water. The Warren filter had an effective sand area of 118 sq. ft. and was supplemented by a settling basin of 13,200 gallons capacity, equal to a 40-minute supply to the filter when the latter was working at the rate of 120,000,000 gallons a day an acre. The Jewell filter had an area of 113 sq. ft. and a 6,600-gallon settling basin, sufficient for a 35-minute supply when the filter was being operated at 105,000,000 gallons an acre a day.

The sand filters were operated 13 months, but owing to delays in negotiation and installation the mechanical filters were in use but seven months. Summaries of the results from each of the four filters, two sand and two mechanical, are given in Tables I. to IV.

TABLE III.—SUMMARY OF RESULTS FROM MECHANICAL FILTERS BY MONTHS.

Months of 1898.	General Summary: Turbidity, raw water	Bacteria, per cu. cm. River water.	Bacteria, per cu. cm. Effluent.	Bacterial efficiency, per ct.	Sulph. of alumina, grs. pr gall. tr'ted‡	Per cent. wash waste.	Rate of filtrat'n, ‡ daily, in million gals. per acre in service.	Water Quantities, Thousands of gallons: Entering water.	Waste before filtration.	Water filtered.	Filtered water for wash'g.	Net available yield.	Hours in use.	Net supply per sq. ft. of filter daily, gallons.	Wash Water: No. of times wash'd	No. of minutes.	Gallons per min. Total.	Gallons per min. Per sq. ft. filter area.	Average quantity fil'td bet. washings. Thousands of gallons.	Average quantity fil'td bet. washings. Million gals. per acre.	Per cent. of Wash.	Per cent. of Waste	Sulphate of alumina used, total lbs.
Warren Filter.																							
January.....	....	.....	...	.....	....	...	115	1,896	34	1,862	89	1,773	141.6	.....	14	195	456	3.9	134	50	4.8	1.8	316
February.....	0.15	9,430	238	97.48	0.70	5.3	104	7,113	108	7,005	266	6,739	597.2	2,031	45	499	533	4.5	156	58	3.8	1.5	701
March.....	0.30	11,747	164	98.60	1.81	4.8	108	8,583	115	8,468	294	8,174	691.4	2,235	48	383	678	6.5	177	65	3.5	1.3	2,183
April.....	0.08	5,010	78	98.44	0.86	3.7	122	9,658	103	9,555	246	9,309	690.7	2,628	43	307	801	6.8	222	82	2.6	1.1	1,166
May*.....	0.19	10,800	630	94.20	1.55	3.4	115	9,519	79	9,440	248	9,192	730.6	2,512	33	332	747	6.3	280	106	2.6	0.8	2,100
June.....	0.19	11,100	115	98.96	1.36	5.1	103	8,265	98	8,167	320	7,847	699.0	2,224	41	412	777	6.6	200	74	3.9	1.2	1,587
July.....	0.11	16,800	320	98.10	1.46	6.5	119	8,239	115	8,124	418	7,706	603.9	2,107	48	521	802	6.8	170	64	5.1	1.4	1,692
August.....	0.36	15,100	290	98.08	1.76	6.4	137	11,306	144	11,162	571	10,591	719.5	2,895	60	659	866	7.3	186	69	5.1	1.3	2,798
Totals and averages.	0.20	11,427	262	97.70	1.36	5.0	116	64,579	796	63,783	2,452	61,331	4,873.9	2,381	332	3,308	741	6.3	192	71	3.8	1.2	12,543
Jewell Filter.																							
January.....	....	.....	...	.....	....	...	85	599	...	599	53	546	64.7	.....	8	131	405	3.6	75	29	8.8	...	62
February.....	0.15	9,430	638	93.23	0.56	6.1	98	6,139	...	6,139	3.2	5,767	580.7	1,822	69	744	500	4.4	89	34	6.1	...	489
March.....	0.30	11,747	208	98.23	1.07	4.3	106	7,875	...	7,875	339	7,536	688.7	2,151	75	519	653	5.8	105	40	4.3	...	1,204
April.....	0.08	5,010	159	96.83	0.54	2.8	106	7,858	...	7,858	224	7,634	687.7	2,251	49	301	744	6.6	160	62	2.8	...	610
May.....	0.19	10,800	150	98.61	1.01	4.6	106	8,246	...	8,246	378	7,868	720.6	2,246	72	508	744	6.6	115	44	4.6	...	1,182
June†.....	0.19	11,100	1450	86.90	1.18	5.4	106	7,834	...	7,834	424	7,410	684.2	2,186	69	572	741	6.6	114	44	5.4	...	1,324
July.....	0.11	16,800	345	97.95	1.31	7.6	103	7,638	...	7,638	577	7,061	687.3	2,016	84	765	754	6.7	91	35	7.6	...	1,423
August.....	0.36	15,100	260	98.28	1.35	6.3	103	7,912	...	7,912	500	7,412	708.7	2,116	61	625	800	7.1	130	50	6.3	...	1,521
Totals and averages.	0.20	11,427	459	95.99	1.00	5.3	102	54,101	...	54,101	2,867	51,234	4,822.6	2,111	487	4,165	689	6.1	111	42	5.3	...	7,815

*Special experiments were made during May. Excluding May, average bacterial results were: Raw water, 11,531; effluent, 201; bacterial efficiency, 98.26%.
†Special experiments were made during June. Excluding June, average bacterial results were: Raw water, 11,481; effluent, 293; bacterial efficiency, 97.45%.
‡The sulphate of alumina used per gallon of net available supply for the year was 1.44 grains per gallon for the Warren, and 1.07 for the Jewell filter.
‡Million gallons per acre daily when in service.

TABLE IV.—Composition of Allegheny River Before and After Passing Mechanical Filters, for Seven Months Ending August, 1898, with Results from Sand Filters for the Same Period.

	River.	Gate chamber.	Mechanical filters—Warren.	Mechanical filters—Jewell.	Settling basin.	Sand filters.—No. 1.	Sand filters.—No. 2.
Turbidity	.....	0.20	0.004*	0.002*	0.14	0.010	0.012
Color	0.26	0.26	0.03	0.03	0.24	0.07	0.07
Alkalinity	2.44	2.56	1.61	1.72	2.49	3.53	3.56
Solids	15.4	15.0	9.3	9.5	11.9	10.8	10.6
Suspended	5.5	4.9	0.00	0.00	1.7	0.00	0.00
Hardness	3.21	3.31	2.92	3.03	3.27	4.31	4.33
Chlorine	1.87	1.73	1.71	1.71	1.80	1.84	1.77
Sulphuric acid	1.15	1.17	1.80	1.67	1.10	1.15	1.15
Iron	0.0320	0.0448	0.0058	0.0053	0.0373	0.0111	0.0145
Nitrogen as: Free ammonia	0.0020	0.0022	0.0019	0.0018	0.0020	0.0018	0.0018
Albuminoid ammonia	0.0101	0.0100	0.0047	0.0044	0.0092	0.0054	0.0053
Nitrates	0.0568	0.0611	0.0512	0.0491	0.0581	0.0642	0.0549
Nitrites	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bacteria	11,337	11,258	201*	293*	9,224	106	148

*Excluding inferior results obtained during special experiments.

The Sand Filters.

Sedimentation Necessary.—With low turbidity the filter receiving raw water did as well as that receiving settled water, but with high turbidity the raw water clogged the filter quickly, the effluent was turbid, and the bacterial efficiency low. For the Allegheny River water it was concluded that preliminary sedimentation "or its equivalent" is necessary.

Covering Unnecessary.—Covering sand filters as a protection against frost is not considered necessary at Pittsburg. The normal January temperature there is about 32° F. The experimental filters were not covered, and the lowest bacterial efficiency during the winter months was an average of 97.18% removal in February, 1898, the coldest month of the season. Winter scraping should be done on the warmest days, to prevent freezing of the sand and poor results. With ample filtering area this can generally be arranged.

Scraping.—Filter No. 1, receiving settled water, was scraped 14 times in 13 months, 77,100,000 gallons of water per acre, on the average, passing between scrapings, with a maximum loss of head of 4 ft. A total depth of 1.064 ft. of sand was removed, or 0.076 ft. (0.912 ins.) to each scraping. The actual amounts removed per scraping ranged from 0.36-in. to 1.56 ins. These depths were obtained Mr. Knowles states, by averaging level readings on numerous points on the bed taken before and after scraping.

The Mechanical Filters.

Coagulant.—The most important factor in the operation of the filters for bacterial efficiency was the amount of sulphate of alumina used, neither the turbidity nor the number of bacteria in the raw water having a material influence on bacterial efficiency, for equal quantities of coagulant. Where turbidity is to be removed the coagulant must be varied according to the degree of turbidity. The quantities of sulphate of alumina required by the Warren and Jewell filters to produce certain bacterial efficiencies under different turbidities is given in Table V. The quantities assumed by Mr. Hazen in making his estimates of operating expenses were averages of the figures for the two filters, as given in the last column. The quantities given in the table are all on the assumption that there is sufficient lime in the river water to neutralize the sulphuric acid in the coagulant. Mr. Hazen presents a very interesting discussion of this matter. He states first that owing to fluctuations in the rates of applying sulphate of alumina it is prudent to use only 75% of the amount indicated as permissible by the lime in the water, but this may be increased in times of very turbid water, as noted below. The average alkalinity, or uncombined lime in the Allegheny River water by months, together with the amount of sulphate of alumina which can safely be used with it, allowing no increase to offset absorbtion due to turbidity, is shown by Table VI., the sulphate of alumina being assumed as 17% soluble.

For short periods the alkalinity went even lower than these figures. The alkalinity is likely to be lowest when the river is most turbid. This raises a point brought out by Mr. Geo. W. Fuller in the Louisville report on filtration, to the effect that the suspended matter absorbs a certain amount of the coagulant. Mr. Hazen doubts whether the increased amount of coagulant plays any part in purification, but states that it must be taken into account in any event. He therefore assumes that with very turbid water the amount of sulphate of alumina may be increased, over the above figures, from 20 to 50%. Even then there will be times when only from 1.2 to 1.5 grains per gallon can be used. In general, these will be at times of maximum turbidity. Lime might be added to increase the alkalinity, but this would increase the hardness. Soda ash could be substituted for lime at considerable addition to the cost, but without increasing the hardness. The use of either lime or soda ash would be permissible only during floods. Without lime or soda ash there are six months in the year when only 1.2 to 2 grains per gallon could be used and several months when it would be impracticable to use the 1.7 grains necessary to attain a bacterial efficiency of 99%.

TABLE V.—Quantities of Sulphate of Alumina Required for Different Bacterial Efficiencies and for Varying Turbidities.

Bacterial efficiency, per cent. removed.	Required amount sulphate of alumina, grains per gallon.—Least turbid waters.	Preceding amount sufficient for turbidities up to.	Extra quantity for higher turbidities throughout year.	Average quantity, throughout year.
	Warren Filter.			
95.0	0.37	0.03	0.33	0.70
96.0	0.44	0.06	0.28	0.72
97.0	0.56	0.11	0.22	0.78
98.0	0.84	0.22	0.14	0.98
98.5	1.12	0.34	0.10	1.22
99.0	1.60	0.53	0.06	1.66
	Jewell Filter.			
95.0	0.42	0.07	0.18	0.60
96.0	0.49	0.12	0.15	0.64
97.0	0.65	0.21	0.10	0.75
98.0	0.96	0.39	0.06	1.02
98.5	1.48	0.70	0.02	1.50

Wasting After Washing.—Regarding the idea advanced by some that the filtrate from mechanical filters should be wasted for a few minutes after washing, Mr. Hazen states as his conclusion, after careful studies of the bacterial contents of the filtrate for 20 minutes after washing, that this wasting is unnecessary. There are more bacteria in the water during this period than subsequently, but the increase is too slight to be of practical consequence, provided only that the filters are carefully manipulated.

Comparison of Effluents Obtained by Slow Sand and Mechanical Filtration.

Bacterial Efficiency.—The average bacterial removals for the two types of filters were 99% for the sand and 97 to 98% for the mechanical filters. For October, 1897, the efficiency of the sand filters was 99.96%. The bacterial contents of the effluents from the sand filters were more constant upon those of the mechanical filters. During the winter months the efficiency of the sand filters fell to 97%. This reduction might be avoided by covering the filters. Likewise the efficiency of the mechanical filters might have been increased by using more sulphate of alumina, the possible increase perhaps being to 99%. The omission of a coagulant results in a drop in the efficiency of mechanical filters, which shows itself as soon as the water without the coagulant appears. This means poor results whenever the application of the coagulant is interrupted for any cause, as by the failure of the alum apparatus to work or the exhaustion of the supply in the feeder.

TABLE VI.—Average Alkalinity and Corresponding Permissible Amounts (Uncorrected) of Sulphate of Alumina.

Months of 1897-8.	Alkalinity, as calcium carbonate.†	Safe amount sulphate of alumina.§	Months of 1897-8.	Alkalinity, as calcium carbonate.†	Safe amount sulph'te of alumina.§
August	4.05	3.79	April	1.83	1.72
September	4.63	4.34	May	2.12	1.99
October	5.09	4.77	June	3.10	2.90
November	3.51	3.29	July	3.41	3.20
December	1.72	1.61	August	3.15	2.95
January	1.48	1.39			
February	1.73	1.62	Average*	2.87	2.70
March	1.75	1.64			

*For year ending July 31. †Parts per 100,000. §Grains per gallon of water.

Clearness of Effluent.—At times neither system can produce perfectly clear effluents. Such occasions are of greater frequency and length for sand than for mechanical filters, but it is believed that poor results could be avoided under either system, with proper care. A moderate amount of storage would render it unnecessary to attempt to filter the most turbid water.

Color.—There is not much color to contend with, and that is reduced somewhat by the sand filters, but still more by the other type. Colors of 0.15 are exceptional. The average color for both sand filters for the year ending July 31, 1898, was 0.07. The color of many (unpurified) Eastern water ranges from 0.5 to 1.0.

Hardness.—Both types of filters increase the hardness, but the mechanical filters increase the permanent and the sand filters only the temporary hardness. It is believed that the effect of the sand filters on hardness will decrease with time, 60% of the carbonate of lime in the sand filters having been dissolved out in 13 months. In another year all the lime might have disappeared. Perhaps sand containing less lime could be found.

Boiler Tests.—Three 25-HP. boilers were tested "for some months," one being supplied with raw water, and one each with water from the sand and mechanical filters, respectively. The raw water produced much the largest quantity of scale, but this scale was soft and readily removed. Both of the filtered waters produced a harder scale, although less in quantity. The water filtered through the mechanical filters produced somewhat more scale than the water from the sand filters and it also attacked the iron in places. The boilers were not operated during the periods of greatest muddiness, and consequently the boiler receiving the raw water probably compared more favorably with the boilers receiving the filtered water than would have been the case at other seasons of the year.

Summary.—The comparison of results, just reviewed, is expressed in actual figures, as follows, for the seven months ending August, 1898, but excluding some periods of special experiments on the mechanical filters:

	River water.	Filters.—Mechanical.	Filters.—Sand No. 1.
Turbidity	0.20	0.003	0.010
Color	0.26	0.030	0.070
Bacteria	11,337.00	247.000	106.000
Hardness: Total	3.31	2.970	4.310
Temporary	2.56	1.660	3.530
Permanent*	0.75	1.310	0.780

*Or encrusting constituents.

Cost of Constructing and Operating Sand and Mechanical Filters.

The estimated cost of constructing and operating the two types of filters is given in Table VII.

The present water consumption at Pittsburg is about 50,000,000 gallons a day. The estimates are based on a 75,000,000-gallon plant. The sand filters would have an area of 25 acres and be uncovered. The cost of covering them would be $375,000 in addition. The estimates for mechanical filters on the South Side include two independent plants and 10% increase in capacity, on account of uncertainties as to the division of consumption between the two.

In estimating the annual cost of maintenance and operation, interest has been taken at 3½%, and depreciation as follows: None on land; intake, pump, boilers and mechanical filters, 3.722%, which at 3% compound interest would redeem the cost in 20 years; buildings, masonry and other more permanent structures, 1.326%, or 40 years for redemption. Mr. Hazen states that no mechanical filter plant which has been in existence for five years would now "be considered as reasonably satisfactory." The type has been so much improved that a greater life than this is to be expected for future plants. Pumping expenses were estimated on an average daily consumption of 50,000,000 gallons. The cost of sulphate of alumina is taken at $25 a ton. This has been placed $2 less than market rates on assurances that for the quantities needed this rate could be secured. The amount of coagulant is low, only one grain per gallon. This is lower than the amount used in the experiments. For higher rates, 18.7 cts. per

TABLE VII.—Estimated Cost of Constructing and Operating Slow Sand and Mechanical Filters.

Cost of Construction.

	Sand filters.		Mechanical filters.	
	With sedimentation basins.	With storage reservoir.	North of river.	South of river.
Intake, pumping machinery and pump house	$315,000	$455,000	$315,000	.....
Sedimentation basin	200,000	.....	.....	.....
Raw water reservoir	.....	442,000	.....	.....
Filters	751,000	751,000	600,000	$660,000
Filter house, boilers, pumps, electric lights, etc.	.....	.....	258,800	400,000
Pure water reservoir	133,000	133,000	133,000	.....
Force main and conduits	78,600	210,300	57,500	467,200
Tunnel under river	60,000	60,000	60,000	.....
Engineering and contingencies, 10%	153,760	205,130	142,430	152,720
Total cost of construction	$1,691,360	$2,256,430	$1,566,730	$1,679,920
Land, with reserve area to double plant	420,000	312,500	75,000	50,000
Total estimated cost	$2,111,360	$2,568,930	$1,641,730	$1,729,920

Cost of Maintenance.

	Filters. Sand		Filters. Mechanical	
	With sedimentation basins.	With storage reservoir.	North of river.	South of river.
Interest	$68,619	$83,490	$53,356	$56,222
Depreciation	28,885	39,277	43,573	40,461
Pumping costs	32,579	40,100	33,533	18,703
Operation*	62,101	45,625	32,120	36,500
Coagulant†	.....	.....	34,225	34,225
Total cost, pr year.	$192,184	$208,492	$196,807	$186,201
Cost, million galls.	$10.53	$11.42	$10.78	$10.20

*Operation of filters exclusive of coagulant.
†1 grain sulphate of alumina.

1,000,000 gallons may be added for each increase of 0.1 grain per gallon.

Other Methods of Filtration.

The Worms Tile.—As already stated, experiments were made with these filters. The results were not favorable, and but little space is given to them in the report. The system is patented, and the reported cost of the plates alone would exceed $1,000,000, without allowances for setting up, piping, or anything else. The operating expenses would probably exceed those of either of the two other systems tested, "and the experiments did not indicate that the requisite amount of pure water could be secured under all conditions."

Asbestos Filter Coverings.—A patented method of applying a carpet of asbestos to sand filter beds was suggested with a view of increasing the yield of the filters and decreasing the cost of cleaning. Mr. Hazen says the plan would "hardly increase the yield or efficiency of sand filters." In case developments show it would decrease operating expenses, it can be applied to the filters at any time.

Filter Cribs and Galleries.—Some interesting studies of the results obtained by a number of filter cribs and galleries located near Pittsburg are included in Mr. Knowles' report. Mr. Hazen believes that, aside from all other considerations, these would be entirely impracticable for so large a supply as an average of 50,000,000 gallons a day.

Separate, Unfiltered Supply for Manufacturing Purposes.—This appears impracticable, largely because of the smallness of the amount of raw, turbid water in demand after filtered water becomes available. Besides, there is always the danger that such water will be used for drinking purposes.

Gravity Supply of Pure Water.—This possibility was investigated and reported on with great thoroughness by Mr. Emil Kuichling, M. Am. Soc. C. E. His figures show, according to Mr. Hazen, that a gravity supply would cost many times more than filtration originally, and 48% more for a period of 50 years, the decreased operating expenses being more than offset than by the heavy capital charges.

The Imperative Necessity for the Restriction of Waste.

In some respects the most valuable part of Mr. Hazen's report is his strong and lucid argument for cutting down waste by the introduction of meters. He shows that in Wards Nos. 1 to 23 all the city except the part supplied by the two small companies (some 8,000 people now), the total water consumption has increased from 20,300,000 gallons in 1883, or 157 gallons per capita, to 42,200,000 gallons in 1897, or 233 per capita. Meanwhile the estimated population in this district has increased from 129,000 to 211,000. He estimates the population in 1900 as 234,000. By 1930 he estimates that the total population in the district supplied by the present city works will be 600,000; in the present city limits, 740,000; within a ten-mile radius, 1,920,000. With consumption increasing at past rates an enormous filter plant would be required in 1930. The real needs of Pittsburg he places as 70 gallons per capita, making two-thirds the present pumpage mere waste, which benefits no one. The waste by the careless is borne by the whole city. The careful users should not be compelled to pay for the water wasted by the careless. With meters, people may waste all they choose and they, alone, suffer. Mr. Hazen earnestly recommends the adoption of the meter system. He suggests that meters should be owned, set and repaired by the city, and that all public institutions be charged for such water as they use above a prescribed amount. In connection with the installation of meters the service pipes should "be given a thorough overhauling."

In concluding his report, Mr. Hazen recommends the retention of the present source of supply and the introduction of meters, as already indicated; a pumping station on the north side of the river, pumping water to 50,000,000-gallon settling basins, from which it would flow by gravity to an effective filtering area of 25 acres, and thence through a tunnel beneath the river to the present, or Brilliant, pumping station. The estimated cost of the work is $1,691,000 for plant, $420,000 for land, and $100,000 for starting the meter system, making a total of $2,211,000.

Professor Sedgwick's Report on Typhoid Fever in Pittsburg.

The records show that during the past ten years typhoid fever has been the assigned cause of 2,245 deaths in Pittsburg, or 225 deaths a year. This is at the annual rate of 81.6 per 100,000, against 21.0 in New York (old city), and 31.9 in Boston. A careful study of the local situation indicates that the most of these deaths are attributable to impure water. The population on the drainage areas has already been reviewed. Professor Sedgwick points out that while the population is quite remote from the intake, the Allegheny for 100 miles above Pittsburg is a swift stream, with few quiet pools. Quiescence is one of the chief means of reducing bacteria in natural waters, hence the dangers from sewage pollution here are unusually great. From Oil City, 113 miles distant, the waters of the river may at times reach Pittsburg in 15 hours, and at most in a few days. The author points out the difficulty of isolating typhoid germs from the much more numerous other species of bacteria. He well says that if

> the typhoid germs were so abundant as to be readily detected, or even detected at all, any city using such water for drinking purposes must surely be depopulated; for even in sewage, in comparison with the whole number of common bacteria, those of typhoid are probably as rare as planets are among the stars, while, unlike the planets, they have no well-marked features of size or motion which enable them to be readily distinguished from their neighbors, but, rather, so closely resemble many of them as to be distinguishable, even when found, only by long and patient study.

This apt comparison is carried still further in a passage well worth noting by engineers for future use in trying to impress upon the popular mind the nature of these deadly foes. It is as follows:

> The germs of typhoid fever bear to the ordinary, harmless germs of sewage some such relation as do murderers to ordinary citizens, in the passing crowd upon a busy street. They are very few in number and outwardly resemble closely the law-abiding. Even expert detectives on the watch may not be able to discover them. It is only afterwards that, unseen and unsuspected, they do their deadly work. Even then they may escape detection in the crowd, and it is only when circumstantial evidence is overwhelming, or when they are taken in the very act, red-handed, that their true character becomes manifest.

In conclusion, Professor Sedgwick states that while a portion of typhoid fever in Pittsburg undoubtedly comes from polluted milk, secondary infection and other sources, yet all the evidence points to some other and more common source of infection. He then says:

> On examining the character of the water supplied to Pittsburg, it appears that it is derived from rapid and turbid rivers, into which abundant sewage finds its way, and by which such sewage is very speedily delivered, unpurified, to the consumers. In other words, the water supplies fulfil precisely the conditions required to explain the facts. I am, therefore, forced to conclude that the water supply is in all probability the principal source of the constant and excessive amount of typhoid fever in Pittsburg.

The Report of Mr. Knowles, Resident Engineer.

Mr. Knowles' report, with appendices containing the reports of Messrs. Riddle, Copeland, Wasdin and Sheperd, gives detailed accounts of the investigations in all their ramifications. The deductions from these accounts, or the most important of them, and the summaries of the tests, have already been given.

One of the most significant things in this report, for future investigators of mechanical filtration, is the statement that five filter companies declined to install and operate their filters during the test at their own expense. These included practically all the companies building filters for city water supplies. The final arrangement with the Warren and Jewell people was a loan of their filters to the commission. In the Louisville experiments the mechanical filter companies installed and operated their filters at their own charge, but the filter companies have evidently concluded that the state of the art no longer throws upon them the whole burden of tests of their filters.

The American rights for the Worms tiles were transferred, during the experiments, to the Wormser Filter Plate Co., of St. Louis.

The Berkefeld Filter Co. submitted a proposition in November, 1897, for placing household filters in all buildings throughout the city. Their estimate for installing 56,000 Berkefeld Home Filters was $560,000, and the annual operating expenses, exclusive of interest, was put at $189,000. Tests of one of these filters showed that a large number of bacteria were removed by it, with careful attention. Frequent washings were necessary, and occasionally the filter cylinder had to be sterilized by boiling.

A feature of the work of the commission was a sanitary inspection of the Allegheny and Monongahela Rivers and their main tributaries, made by eight students of the University of Western Pennsylvania during the summer vacation of 1896. The inspection showed a large amount of sewage pollution, even on the headwaters of the rivers.

Analyses of sand from various depths in the sand filters, after 14 months of use, are presented by Mr. Knowles in detail, and condensed herewith, for Filter No. 1, which received settled water, as follows:

Depth below surface.	Per cent. calcium carbonate by weight.	Bacteria per gramm.	Ammonia, parts pr 100,000 Albuminoid.	Ammonia, parts pr 100,000 Free.
½-in.	0.39	2,440,000	11.00	3.50
1 in.	0.21	340,000	6.00	2.50
2 ins.	0.45	230,000	3.00	3.25
3 "	0.30	100,000	2.20	0.50
4 "	0.27	60,000	1.00	4.00
8 "	0.61	32,000	1.50	2.00
16 "	1.00	20,000	2.00	1.20
28 "	0.48	8,400	1.20	0.90
36 "	1.57	10,000	1.20	1.00
Averages*	0.53	168,000	2.22	1.25

*Not of above figures, but including additional ones to complete observations for every 2 ins. in depth, from 4 ins. down to the bottom, or 36 ins.

The Filtration Commission, in transmitting the reports of Mr. Hazen and the others to the City Council, endorses his recommendation for sedimentation, slow sand filtration, and the introduction of meters. It advises a loan of $3,000,000, to be used approximately, as follows: Filtration and accessories, $1,700,000; land, $500,000; meter system, $800,000; leaving a contingency fund of $200,000. It urges that the use of meters may be expected to so cut down the waste as to make it possible for the present works to supply the water needed by the customers of the Monongahela Water Co., and to effect such savings in operation as would help pay for the cost of filtered water.

STORAGE BATTERIES AND RAILWAY POWER STATIONS.*

By Robert McA. Lloyd, M. Inst. Elec. E.†

A difficulty confronting manufacturers of accumulators is that very few operators of electric railway power stations have any data showing what their stations are doing. Managers of electric light stations seem to take more interest in the output of their stations, and in many cases maintain a complete system of records, but the manager of a trolley road is usually contented with superficial observations of the switch-board and the comforting fact that the cars are running, and they are greatly surprised when the actual state of affairs is shown to them on paper and the results of a thorough research into the load curves of the railway plants of the entire country would astonish many members of the Institute. The average load on a railway power station for a given period is much less than the maximum load occurring during that period and much more than the minimum, but it is not generally understood that the maximum load for the same period is apt to be far below the capacity of the generating plant in operation. This is, however, practically true for all railway plants in this country, so far as the experience of the Electric Storage Battery Co. has gone. The first explanation of this would be that such a surplus capacity is necessary for reserve to meet emergencies, but it does not always appear that this is the case. In a certain plant, operating 35 cars, which I have selected as a typical railway station, there is no reserve from the standpoint of the manager, engineers and attendants. In fact, the station is dangerously overloaded, and yet notwithstanding this and the added fact that the test was made on the day of heaviest travel in the whole year, the highest or maximum current demand was within the capacity of the main station. Among some of the interesting features of the data obtained was noticed the fact that the nominal capacity of the generating apparatus was about 400 K-W. in excess of its maximum output, occurring at about 8 o'clock in the evening, and that the average output at this time was about ⅔ of the maximum.

It will doubtless occur to some that this station apparatus has been overrated, or that the engineer was incapable, or over cautious, but the fact remains that similar data are obtained in very many stations, and that in many cases the apparatus has been subjected to satisfactory tests before acceptance by the purchasers. It may be possible to build engines which regulate at all conditions of load and at the same time use steam satisfactorily at maximum load, but I do not find such engines commonly in use. Experience convinces me that the men who are most likely to be consulted about such a station will recommend more generating plant, and the truth is that there are so many good salesmen pushing engines and dynamos that station managers frequently fail to get full duty from the machinery which they are operating already, and any of us can see railway power houses throughout the country, where the managers have been persuaded to increase their generating plant when attention to a few details, such as steam piping, would have brought their output up to requirements. Assuming, however, a station, equipped with the best obtainable apparatus, and operated under the most advanced laws of station practice, in the absence of a storage battery, there would still be much more apparatus running than would appear necessary from the load diagrams.

The generator salesman says in reply to this proposition that his apparatus is cheap, and that it is good to have plenty of it, but one generally finds that where there is plenty of apparatus available the engineer is tempted to keep too much of it running, and therefore running at low efficiency. Of course, railway power stations have individual characteristics, and it will not do to assume that they all need storage batteries, but there are certain features of railway power requirements which are common to the problem elsewhere, and which invite consideration for the storage battery.

The curve characteristics of electric light supply are well known, and much information about electric lighting has been brought out in the committee reports of the National Electric Light Association for 1896 and 1897, and by Mr. Hammond in his paper before the British Institution of Electrical Engineers in March, 1898, but the possibilities are more varied in railway work, and, as far as I know, there has yet been no systematic research into the economy of railway power stations, the only published data on the subject being contained in the paper read before the Street Railway Convention at Boston last September by Mr. W. R. Conant.**

To show the application of the storage battery to electric railway operation I have, as already stated, selected a road located in a Pennsylvania town of about 50,000 inhabitants. The railways radiate from the center of the town to distances of 3 to 9 miles. There are 6 branches and the power station is located 2 miles out on the longest branch. It has railroad and water frontage. There is also a small auxiliary power house close to the main house, which is the result of a recent consolidation. There are three distinct ways of using a storage battery with this power station. We find that the output is disturbed in three ways: First, a great fluctuation between night and day loads; second, by the fluctuations occurring from hour to hour; and lastly, the superimposed fluctuations occurring from moment to moment. We shall call a battery of sufficient capacity to level off the night and day fluctuations "large"; a battery for leveling the hour to hour fluctuations "medium"; and a battery to level the momentary fluctuations "small." The small battery will reduce the requirements of the generating plant to a capacity sufficient to meet the demands of the average load. The battery must be able to discharge a current equal to about ½ the maximum load, or about ⅔ of the average load for momentary periods, but its capacity in ampere hours is unimportant. It will cost less than generating capacity for the same work, and a large part of the excess of capacity over requirements will be saved. It will save some depreciation on the generating apparatus, and its own depreciation will not cost more than the depreciation of generating apparatus of similar capacity. It will have sufficient storage capacity to run a few night cars and lights when the engines are shut down. If located at a point nearer the center of feeder distribution than the location of the generating station, a saving in copper will be effected. Inasmuch as the investment will not be increased by including such a battery in this railway outfit all the saving in fuel due to a steadier load and the operation of less generating machinery will be clear gain to the credit of the battery.

A "medium" battery to reduce the load on the generating machinery to a constant value for 18 hours per day will cost about twice as much as a "small" battery, but will not add enough to the cost of the installation to bring the investment up to the total now in generating apparatus alone and presumably necessary if no battery is used. This battery will have all the advantages of the small plant with wider limits of operation. The station circuit breakers may be set as many amperes higher as the ampere capacity of the battery, and there will be greater convenience throughout the station in operating at a fixed load. There will be a marked effect on the efficiency of all departments of the station, and all the apparatus will yield a higher output in proportion to investment and cost of operation.

Assume the engines and generators to run continuously on an average load for 24 hours and a "large" battery capable of leveling off this load will have a capacity in ampere hours of over twice that of the "medium" battery. It will cost approximately twice as much as the "medium" battery and will have all of its advantages. It will cost as much as the generating machinery displaced by it. It will add largely to the flexibility of the station. This battery will be discharged momentarily at maximum capacity, permitting the circuit breaker limit of the station to be raised over 50%. It may be discharged for one hour at a rate which will be sufficient to cover load peaks that would stall the generating plant completely.

In cases of extreme necessity the entire system might be carried by this battery for several hours. The ability to carry sharp peaks is a distinct addition to the earning power of the system. Such peaks often signify the collection of fares which would be lost if the system were not flexible, and some managers keep up enough station capacity to carry a few holiday crowds while for 99% of the whole year it is earning nothing. Other managers do not attempt to carry special crowds. The large battery will give the manager an opportunity to get all the money that can be made out of such business without feeling that he has made any investment for the purpose. Of course the capacity of the system is limited also by the investment in copper, but in many cases the battery may be located so as to facilitate the distribution of power.

There is no reason why a railway power station of this capacity running night and day at a constant load should not attain a fuel economy as high as that of the well-known Chestnut Hill pumping station at Boston, which would be equivalent in electrical work to 557 watt-hours per pound of coal. In the test of this 35-car plant 1 day's work was found to equal 7,800,000 watt-hours which required, at the above rate, 7 tons of coal. Assuming that the battery would only have 75% efficiency, and that 25% of the entire day's work would go through the battery, ⅓ ton of coal would be added to this consumption, making 7⅓ tons of coal per day for this plant running with a large battery.

The battery efficiency in such service as this has been found in most cases much higher than 75%, and in some cases over 90%, so this estimate is clearly on the safe side.

On the day when these data were obtained 15 tons of coal were burned, or twice as much as would be necessary with the battery outfit. The battery would therefore save at $2 a ton $5,474 per annum in coal alone.

The number of men in the station is now the same night and day and there would certainly be no increase in the labor item, whereas it is probable that one man on each shift might be dispensed with if the plant were reduced by the battery, in which case there would be another saving of $1,200 per annum. The battery would also save water, oil, waste, etc., and there would be minor advantages such as more constant potential on the line; less annoyance from circuit breakers opening; no fear of sudden demands on the generating apparatus, and the disagreeable possibilities incident thereto.

With regard to the "small" battery, there is no doubt of its advantages in many cases, but for new installations it is not always the most economical battery. I understand that Mr. Leslie Carter, the President of the South Side Elevated Railroad Co., Chicago, Ill., said recently that, as far as he knew, their battery did not save anything in the cost of operating the road, but that they could not run without it, and I take the liberty of making the following extract from his annual report to the stockholders, which has since been published:

> While the amount of current used per car mile is low and has produced gratifying results in all tests and comparisons made, the fluctuations of power above the average requirements are large, and the sudden demands on the power-house compelled us to prepare promptly for the heavier business of the winter, which, with increased number of cars in service, heat, and light loads, would have been beyond the capacity of the power-house. Additional engine capacity could not be obtained in the time at our disposal, would have cost more money, and have been expensive to operate. We accordingly installed two batteries of 750 K-W. each, equidistant from the power-house, at 12th and 61st Sts., respectively. These batteries have greatly reduced the fluctuations and the maximum load at the power-house. While the output at the power-house is the same, the batteries charge at times of light traffic and discharge at times of heavy traffic, thus equalizing the work at the power-house, and relieving the engines and generators. This is certainly an economy, and it is further claimed, with what correctness I am not yet convinced, that they cheapen the cost of production. But I do know that they keep up the voltage at the ends of the line, enable your road to operate more cars, furnish increased facilities to patrons, and prevent damage to power-house machinery in case of sudden demand for increased power.

The battery referred to was, of course, put in for regulating purposes only, and the load curves give the impression that the battery must certainly be useful. It seems to me hardly worth while in laying out a new station to but in a battery for the purpose of reducing the railway power curve to the characteristics of electric light practice, when by going a few steps further it may be refined to a practice comparable with marine engineering.

It might appear at first thought that a battery of sufficient capacity to insure a full load for the generating units at all times would save as much fuel as a battery large enough to level off the 24-hour service, but it is very difficult to follow the power requirements from hour to hour in such a way as to make ideal use of a battery whereas with a "large" battery it would be possible for the ordinary station engineer to adjust his load so as to operate all of his apparatus to the best advantage all the time.

I have carefully analyzed the figures in Mr. Conant's very interesting paper above referred to, and am compelled to differ from him at some points, and refer to them in order to meet in advance any criticism of my paper which may be based on his tables. In the first place he assumes that his standard station can be worked all the year round with a load factor of 33⅓%, which is entirely too high; 20% or 25% would be more normal. I suspect that Mr. Conant's load factors have been obtained by indicator cards instead of wattmeters. In Mr. Conant's table none of the stations show a better figure for coal than 3 lbs. per kilowatt hour, while his standard station is put down for 2.2 lbs., without any intimation of the process for attaining such a good result. The question as to how the cost of repairs and depreciation of the entire plant would be effected by a large battery is particularly debatable ground. Mr. Conant allows 2% for depreciation beyond the normal running repairs. He estimates the entire plant, including buildings, to last 50 years. His statement that the machinery now being installed will last much longer than that with which we have been familiar in the last decade has nothing to back it up except faith in the promises of the builders.

I propose to allow 10% per annum for repairs and depreciation, on the entire station apparatus, including batteries. I have not seen any boilers that are likely to last 50 years, and there is plenty of evidence that all the best engines and boilers in this class of service to-day will go to pieces in a life of from 10 to 20 years. The particularly hard usage to which most of them are subject is not only steadily wearing them out, but producing a state of constant danger and not infrequent accidents. I am sure this is becoming well understood among railway men, and some of the best managers are writing off to depreciation 10% per annum. Moreover who can say that improvements will not be made in the next 10 years as in the past, and that engines and boilers may not be out of date before they are used up?

It is of course well known that whatever the rate of depreciation may be without batteries, it will be lowered by giving the generating apparatus a constant load; my belief is therefore that the storage battery will not increase the rate of depreciation for the entire plant. If it can be shown that interest and depreciation for a plant of given load dimensions are practically equal with or without a large battery, it is evident that the great saving in fuel alone will determine the superiority of the battery system.

I have so far considered the battery only at the central generating station so that all the advantages due to locating it at proper points in the distribution system are additional arguments in its favor. In many cases the

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*Abstract of a paper read before the American Institute of Electrical Engineers, Feb. 15, 1899.

†22 Broad St., New York city.

**Engineering News, Sept. 22, 1898.

saving in copper may be greater than the sum invested in the battery, and the flexibility of the system improved in places where it would not pay to install sufficient copper to meet the irregular demands of travel.

The reserve qualities of the storage battery are unique. It might be supposed that a mere reservoir which is quickly drained would be of little value compared to a lot of extra generating apparatus standing idle, but experience is demonstrating every day in existing plants that the reserve which is needed most is the reserve which is not only ready for emergencies, but actually alive to any demand without the direction of a human mind.

Alternating currents lend themselves readily to the development of storage battery applications on account of the mutually helpful combination of battery and rotary at sub-stations. Up to the present time, each of the large batteries installed for railway work has been obliged to meet different conditions, and requirements, but they are all serving their respective purposes well, and showing many different fields of usefulness.

Most of us feel that the electric railway and electric lighting interests are destined to get into closer relations, and the generating station of the future may be required to furnish all the electricity used within large areas for every purpose.

Electricity has so many advantages over any other medium for transmission and storage of energy that I assume its use to be firmly established, and cannot conceive of any lasting rivalry by the other contestants now in the same fields. Further than this, without saying anything for or against monopolies, I believe that all the energy supplied by means of electric currents to consumers of every nature in the Greater New York should radiate from two or three central stations, and that these should be electrically tied together. The sub-stations would naturally consist of rotaries and storage batteries. It may not be possible to lay out each sub-station so that the rotaries would run at a constant load for 24 hours a day, but it seems to me quite probable that such an arrangement would eventually be reached, and this would of course give the generating stations a constant load. The railway and light people recognize the importance of leveling up some portions of their load curves, but I estimate that the greatest saving is to be obtained by operating for a constant load 24 hours per day. However high would be the economy of such large stations, I am sure it would be higher with large batteries than without. Certainly the economy of the Boston pumping station as to fuel consumption should be surpassed. It must not be assumed that a high load factor for the system is an advantage. It is all right for the generating plant and for the copper feeders, but the kilowatt hours that bring in the most money, may spoil the looks of the load diagrams and kill the load factor. What is required to earn dividends is a profitable load factor outside of the stations, whether high or low, and the highest possible load factor at the dynamo terminals. The large storage battery meets these two requirements perfectly. A load factor of 100% may be maintained at the dynamo, and current may be sold to the consumer regardless of the time of day.

DISCUSSION.

The discussion which followed the above paper corroborated the author's statements. Mr. Geo. S. Hill gave perhaps the best instance of the advantages of a large storage battery plant. A 6-story office building, 75 x 100 ft., formerly requiring annually between 350 and 400 tons of coal for all purposes was equipped with two sets of storage batteries, each with twice the capacity of the generating apparatus. The entire load upon the engines is simply that of charging one set while the other was discharging. The battery equipment is sufficient to take care of lights, elevators, ventilators, etc., for 1½ days should any accident happen to boilers, engines or generators. The plant is now using 118 tons of coal per year. From this and other experience he favored large storage battery equipments, and did not believe that any considerable amount need be allowed for depreciation, provided the battery was under the care of a competent man.

Others regarded the preponderance of battery over generating equipment as essential to best results, but considered an allowance of about 10% for depreciation as advisable—the real value being between 6% and 8% for this country, and apparently as low as 4% in Berlin, Hamburg and other German cities. A comparison was made between gas and electric companies, the large gas holders from which the supply was taken by the user regardless of how the gas was generated was the ideal system; a large storage battery plant and less generating apparatus would accomplish the same result.

WATER POWER DEVELOPMENT ON THE CHICAGO DRAINAGE CANAL.

We have several times referred to the importance of adopting some plan of utilizing the power developed by the flow of water through the Chicago Drainage Canal, and as the Trustees and the Chief Engineer recognize that this will be an important accessory feature of the canal, it seems probable that some plan for utilizing the power will be carried into effect. The original plans for the tail race included provision for a dam and site for a power plant, but as these plans were for a route that was objectionable in many ways, the Chief Engineer opposed their adoption, and ultimately with success. The particulars of this we shall give shortly in an article describing the tail race as now being built upon the new route. No water power project is now included in the tail race, but the Trustees of the Sanitary District have had under consideration the development of power at Joliet or Lockport. The Trustees, however, have no funds available for this purpose, and it was proposed to advertise for propositions for the utilization of the power at the latter place. This plan has been abandoned, but instead thereof the Trustees instructed the Chief Engineer to send out letters on the subject to men interested in this class of improvement. We are indebted to Mr. Isham Randolph, Chief Engineer, for a copy of the letter, which is given below, substantially in full.

The Sanitary District of Chicago desires to call attention to the fact that, among other important results growing out of the work which it has been prosecuting and which is now rapidly nearing completion, a situation will exist at or near Lockport (Will county), Ill., which can be made to afford a water-power development of very considerable magnitude. The minimum volume of water delivered at this site will be 300,000 cu. ft. per minute, which, to comply with the law under which this District is created, must be increased to 600,000 cu. ft. per minute. Under proper construction a fall of 34.5 ft. can be secured with a flow of 300,000 cu. ft. per minute. This head would diminish with the maximum flow (for reasons which will be explained to those investigating this subject), to about 25.5 ft.

This site is about 30 miles from Chicago, and the Sanitary District owns a continuous and ample right of way extending from the proper location of the power plant to Robey St. in the city of Chicago (six miles via the Chicago River from Lake Michigan.) The Engineering Depratmen tof this District has prepared, by way of suggestion, general plans for this project and presents estimates as follows of the quantities of work involved in the preparation of head and tail race and wheel pits:

Rock excavation for head race.....	142,081	cu. yds.
Masonry in walls for head race.....	168,447	" "
Masonry in dam for head race.....	37,867	" "
Back filling for walls	668,500	" "
Rock excavation for tail race.....	2,242,800	" "

In addition to the development just described this District owns the right to develop water power at or near the mouth of Hickory Creek, adjacent to the southerly limits of the city of Joliet. At this place a fall of 6 ft. can be secured by building a proper dam, and this can be increased to 20 ft. by excavating a tail race to Lake Joliet, 4,000 ft. distant. The volume of water available for this second development will be practically the same as that afforded at Lockport. It is the desire of this District to lease the power privileges at both of these sites to responsible parties upon the best terms to be secured therefor, and it invites your consideration of both projects with a view to a contract under which you will fully develop the power which it is possible to create.

The District owns ample lands for the establishment of factories near the power development, but if it is deemed more profitable to transfer the power by electrical transmission to Chicago a right of way as far as Robey St. will be provided for that purpose. It must be remembered always that the volume of flow for this development will be drawn from Lake Michigan, subject to absolute regulation and free from all the fluctuations to which other powers are subjected by drought or flood. While it is expected that persons seeking to make and control these developments will offer proposals on lines which seem to them most advantageous, it is proper that a plan should be outlined for your consideration, and the following is submitted:

The Sanitary District to lease the water rights, the lands necessary for power plant and right of way for electrical transmission upon the basis of $..... per HP. capable of being developed by the volume of water supplied, at the head made available. The lessee to furnish the money necessary for the creation of the head and tail race, turbines, motors and other equipment. The cost of the head and tail race and wheel pits (being a permanent improvement) to be paid out of the agreed rentals. The Sanitary District to receipt to the lessee each year for the rental and the lessee to credit the amount of the same upon the entire cost of the head and tail race and wheel pits until the full amount shall have been paid; after which time the rentals shall be paid in money to the Treasurer of the District. All construction must be in accordance with plans approved by the Sanitary District and the work must be done under the supervision and with the approval of the Chief Engineer of the District, who must certify to all expenditures made for the work, to the end that the Sanitary District may be fully advised of the actual cost thereof. Any plan for creating these powers must be developed in harmony with the use of this channel for navigation, and no lease will be granted which does not reserve the right to use sufficient water for lockage. While it seems hardly possible that any development for power purposes could infringe upon or militate against the usefulness of the channel as a great sanitary agent, yet such a possibility must be recognized and fully guarded against. Prompt action is very important.

NOTES FROM THE ENGINEERING SCHOOLS.

Massachusetts Institute of Technology.—The 34th annual catalogue shows that there are 1,171 students in the Institute this year, as compared with 1,198 last year. There is a loss of 22 women in the biological class, and of 27 women in all departments, which just equals the loss in the total number of students. Four graduates are pursuing advanced studies in Europe on institute fellowships. The classification of students in the last three years of the four years' course is as follows: Mechanical engineering, 162; civil engineering, 140; electrical engineering, 104; mining engineering, 66; architecture, 112; chemistry, 72; chemical engineering, 43; naval architecture, 39; biology, 25; physics 8; geology, 5; general studies, 14. The students come from almost every state in the union, and there are 28 students from eleven foreign countries.

Lehigh University.—Summer schools in chemistry, physics, surveying, mathematics, English history, political economy and ancient and modern languages are proposed to be held during the coming summer if there are a sufficient number of applicants to justify the formation of classes. The instruction will be mainly adapted for teachers in secondary schools. The courses will be from four to six weeks in length and will begin on July 6.

In chemistry courses will be offered in general laboratory experimentation and in qualitative and quantitative analysis. In physics there will be lectures in theoretical and experimental physics; laboratory practice in general physics, including electricity and magnetism; also in the design and construction of simple physical apparatus involving work in the shop; dynamo laboratory practice, including electrical testing. The course in surveying and leveling will embrace the elementary theory of land surveying with practical work in the field and drawing room. The fees for the several courses range from $15 to $25.

The non-resident lecturers for the second term 1898-99, and the titles of their lectures are the following: Joseph Wharton, of Philadelphia, on Tariffs and Tariff-Making; Capt. E. L. Zalinski, U. S. A. (retired), on Fortifications; F. H. Newell, Chief Hydrographer of the U. S. Geological Survey, on The Hydrography of the United States; John Sterling Deans, Chief Engineer of the Phoenix Bridge Works, on Experiences and Lessons from the Life of a Bridge Engineer; Professor John Bach McMaster, of the University of Pennsylvania, on Political Methods in the United States a Century Ago. The department of mechanical engineering has lost the services of Messrs. B. H. Jones and L. O. Danse as Instructors, and their places are filled by Messrs. L. N. Sullivan and J. C. Peck.

Purdue University.—Mr. Robert S. Miller has been appointed Assistant Professor in charge of the department of Machine Design, and Mr. L. V. Ludy has been made Assistant in the Engineering Laboratory, assuming the work which has hitherto been carried by Mr. Miller.

Mr. Miller is a graduate of the school of Electrical Engineering, class of '95, and received the degree of Mechanical Engineer from the same institution in '97. Since graduating, he has been assistant in the Engineering Laboratory, and later Instructor in Mechanical Engineering. In addition to his routine work at Purdue he had a leading part in the exhaustive series of tests made two years ago at Purdue upon the balanced compound locomotive, and last year was in immediate charge of the fuel tests made at the University for the Big Four Road, and still more recently assisted in the duty test of the 20,000,000-gallon Snow pumping engine at Indianapolis.

The Master Car Builders' Association has turned

over to Purdue University the work of testing the comparative strength of the U. S. standard and Manufacturers' standard bolt head. It has been urged that the attempt to upset a bolt to the thickness called for in the U. S. standard will result in a weakness of structure where the bolt joins the head. Bolts ranging from ¼ to 1¼ ins., of both standards, from eight different manufacturers will be tested, (a) in direct tension to pull off the head, and (b) in eccentric bearing to open up the bolt at the junction between the head and the shank. In all, about 500 bolts will be tested.

Other investigations on hand in the laboratory this year are: The effect of temperature on the coefficient of friction of brake shoes. The M. C. B. Brake Shoe Testing Machine recently set up in the Railroad Laboratory will be used for this purpose. A study of the action of air in the air-brake, using the Air-Brake Testing Plant which is now installed in the Railroad Laboratory. This plant includes the cylinders and piping for two trains of 50 cars each, so arranged that the time of application of the brake at different points of the train is recorded on a chronograph. The pressures at different points are also measured.

On the locomotive "Schenectady No. 2" a series of tests is being run to determine the effect of pressure on steam consumption at constant speed.

The standardization of the rattler test for paving brick, and the effect of temperature on impact tests in tension are other subjects under investigation.

The Westinghouse Air Brake Co. has presented the Laboratory with section models of triple valve, engine valve, and pump governor. These are mounted in connection with the Air-Brake Testing Rack.

Stevens Institute of Technology.—The mid-winter meeting of the Alumni Association of the Institute was held in Hoboken, N. J., on the evening of Feb. 15th.

The date was the anniversary of the destruction of the "Maine," and a large part of the session was devoted to illustrated addresses by some of the graduates who had acted as engineers during the recent war. Of the many graduates who volunteered, 33 were accepted and acted in various engineering capacities throughout the war.

The first speaker was to have been Prof. W. S. Aldrich, Professor of Mechanical Engineering in the University of West Virginia, who was stationed on the repair ship "Vulcan," which was of such invaluable service. Unfortunately, Mr. Aldrich was "snow bound" on his way and did not arrive in time. The substance of his address will, however, appear in the next number of the "Stevens Indicator."

The principal speaker was Mr. Alexander Dow, M. E., who was a member of the Engineering Corps recruited from the ranks of the American Institute of Electrical Engineers. Mr. Dow and his companions accompanied the troops sent to Porto Rico and was there engaged in much lively engineering work during the landing and advance of our troops.

His remarks were illustrated with photographs taken on the ground, and were enlivened by the description of numerous amusing incidents of the voyage and campaign.

President Morton made a brief address on the subject of the Alumni Building Fund, which has been allowed to lie quiet during the business depression of the last few years. The cash in hand of this fund has already accumulated to nearly $20,000 and the shares of stock which he had himself donated to this fund at the time of the 25th anniversary in 1897 are now salable in the market for over $20,000 more.

Prof. Jacobus, who occupies the chair of Experimental Mechanics and Engineering Physics, explained certain drafted plans for a new building which he had prepared, and the proposed arrangement in it of the apparatus and machinery. The matter of the new building was left to the Executive Committee to take such steps as it might think advisable towards securing sufficient funds to warrant the erection of some such building as had been described.

The question of the desirability of an annual dinner of the Alumni, to be held in New York city, after the expressions of approval by a rising vote, was also left in the hands of the Executive Committee for further action.

Two graduates of the Institute, Messrs. Frederick N. Connet and Walter W. Jackson, of Providence, R. I., have received the John Scott Legacy premium and medal from the Franklin Institute for their invention of a registering apparatus for the Venturi meter. The report of the Committee on Science and Arts, which recommended the award, and a complete description of the meter and the registering apparatus is published in the February number of the "Journal of the Franklin Institute."

ROAD-BUILDING IN NEW JERSEY.

Road-building by State aid, says State Commissioner of Public Roads, Henry I. Budd, in his fifth annual report, is steadily progressing in New Jersey. Beginning with 1895, the annual progress is represented by the figures of 46, 50, 70 and 85 miles, or about 251 miles in all. The principal construction in this State has been in the direction of roads 4, 6 and 8 ins. deep; as experience has shown that properly drained earth is a sufficiently good foundation for any road superstructure, and all that is wanted is enough "metal" on the surface to stand up under the wear until the roads have to be resurfaced. This happens when the roads are subject to two or three inches of wear. To cheaply maintain the surface, an application of coarse sand, or gravel, and loam containing oxide of iron will keep the surface in good condition and make a soft cushion for the feet of horses. This coating prevents the powder binding the stones from blowing away, and keeps the trap-stone dust sufficiently moist to maintain its cementing qualities. On many of the roads, where the traffic is mainly moving in one direction at a time, a width of 8 ft. is found amply sufficient for a macadam or gravel road; where the road is more important 16 ft. will do for the width. But Mr. Budd thinks that a minimum width of 10 or 12 ft. would be better than 8 ft., as the traffic would not be so closely confined to one track, and the edges of the roadbed would be less likely to be pushed out. Drivers should also be instructed not to follow one line in using a road, as this practice tends to form ruts—the great destroyers of roads. The road authorities of New Jersey have, therefore, settled upon widths of 10, 12 and 14 ft. in the country, and 16 ft. in the towns, as the limits for roads built through State aid; if the citizens want wider areas covered, they must do the remaining work at their own cost.

The Jersey roads are now costing from 20 to 70 cts. per sq. yd.; and in wet places, where telford is necessary, the cost reaches 73 cts. In the lower part of the State, in 1898, the cost ranged from 50 to 60 cts. In Morris and Passaic counties, in the upper part, the bed of stone is 4 and 6 ins. deep, and the cost ranges from 20 to 45 cts., with the stone taken from points near the road. The contract price of roads in New Jersey ranges from $3,000 to $5,000 per mile; and a continuous gravel road, 34 miles long with a 7-mile branch, was built for about $1,400 per mile. The endeavor in State road construction is to provide continuous avenues of travel. There is now nearly completed a hard road running from Atlantic City to Jersey City, and from Jersey City to the extreme western boundaries of Morris and Passaic counties. Many lateral roads leading to these lines have been improved. Other systems are being built from Trenton; three of these being finished and terminating —at Somerville—where it connects with the northern road system; at Kingston, to be extended to Somerville and New Brunswick; and at Edinburgh, also to be carried to New Brunswick. From Camden there are seven continuous lines leading to the more important towns south and southwest of Trenton; other lines radiate in Monmouth Co., from Paterson and Newark, from Morristown, etc.

In commenting on the benefit realized by farmers from these improved roads, Mr. Budd makes the following statement: Before the advent of stone roads the leading highways, not gravelled were almost a bed of sand, and teams carried 40 or 50 baskets of produce to the Philadelphia market with difficulty. Farmers shipped produce mainly by railways and boats as being the cheaper method. Since the roads have been macadamized, leading towards Gloucester City ferry, from 1,600 to 1,900 teams pass daily, where 200 to 400 was the previous maximum. These teams now carry from 130 to 175 ⅝-bushel baskets of produce; where they carried from 30 to 50 baskets before. The farmers now cart to market, instead of sending by boat, and return with from 3 to 5 tons of manure, and thus effect a large saving. The average cost of sending a basket of produce by boat to the Philadelphia markets was 6 to 8 cts.; the items of expense being 3 cts. for freight, 3 cts. for attendant and 1 to 2 cts. for carting in the city. If the commission were added, the cost would average from 11 to 12 cts. per basket. When carting an average load of 150 baskets, the farmer saves by the use of his own team about $10 per day; or $50 for a week of 5 days, less ferry expenses of 75 cts. per day. By marketing his produce the farmer also saves a commission of 10%, or about $6 on 150 baskets. It is interesting to note that whereas Gloucester Co. at first sent in numerous protests against the enforcement of the Stone Road Law, and asked that the forcing clause be stricken out, applications for roads from that section are now so numerous that it is impossible to come anywhere near meeting the petitions.

While this whole report is teeming with useful information and is in itself an excellent treatise on modern road-building, we must refer our readers to the report itself for full details. One of the very instructive portions of the report is the detailed description of roads improved in 1898. Here we have in each case the type of road constructed with its dimensions; the source of the road material; the kind of country traversed by it; maximum grades, and the cost per square or cubic yard, along with the total cost. These details are so very complete that they will serve as a basis for estimates of similar pieces of work, the cost of labor being adjusted. The report is profusely illustrated with photographic views of highways "before and after" taking the State aid cure.

Mr. Budd discusses the acquisition of all roads for free public use, trolley lines, motor vehicles, the necessity of improved roads to retain rural population, tire-widths, etc. And he also tells what is being done by Highway Commissions in other States, and concludes with extracts from or full papers by engineers on the various phases of highway construction. An appendix gives in full the amended form for specifications for road construction under State aid, and the text of the New Jersey State Aid Road Law. Our readers desiring to secure copies of the report should address Mr. Budd, at Trenton, N. J.

THE TELEPHONE BUSINESS IN MICHIGAN, says the "New York Commercial," is developing some interesting features. In 1883 the Bell Telephone Co. began to extend its operations in the Lake territory and the Michigan-Bell Telephone Co. was organized with $100,000 capital, and $68,000 paid in. The lines were built, and having a monopoly, the profits grew so rapidly that the concern was recapitalized at $2,500,000 and the name changed to the Michigan Telephone Co. The stock was sold, but soon after the people rebelled at the high charges imposed, and in 1893 when the Bell patents expired, independent companies were organized by leading citizens. There are now 26,000 independent telephones in the state, with all the separate companies working together under a 25-year agreement. These independent companies charge $40 per annum for business houses and $25 for private houses; and in smaller places the rates are $24 and $18. The Bell Co. has reduced its rates below these, and in some cases makes a rate of $6 per annum. Meanwhile, says the "Commercial," the Michigan Telephone Co. stock has been watered and the property mortgaged and sold three times, for $2,500,000, $750,000 and $2,000,000, and now it is being "reorganized" again in an attempt to secure $2,500,000 more. The general purport of the "Commercial's" criticism is that the independent companies control the situation in Michigan, and that the new issue of Michigan Telephone Co.'s bonds does not promise dividends.

THE NEW YORK FOREST PRESERVES, during the past year, were increased by the purchase of 309,803 acres of land, for which $1,304,572 were paid. The expenses of the Forest Preserve Board for 1898 were $30,027. The price paid per acre varied from $1.50 to $7.00, the latter price being allowed for totally uncut timber land. Included in the late purchases was the upper half of Saranac Lake, with over forty other lakes and ponds; this territory is extremely valuable for cottage and camp sites, and the price paid $6.02 per acre. A tract of 30,000 acres, in Franklin county, was purchased at $5.50 per acre for the State College of Forestry, connected with Cornell University. This was in accordance with the late act of the Legislature providing for the establishment of this College of Forestry.